ION/CME Digital Drive
User's Manual

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Related Documents

Magellan Motion Processor User's Guide

Complete description of the Magellan Motion Processor features and functions with detailed theory of its operation.

Magellan Motion Processor Programmer's Command Reference

Descriptions of all Magellan Motion Processor commands, with coding syntax and examples, listed alphabetically for quick reference.

Pro-Motion User's Guide

User's guide to Pro-Motion, the easy-to-use motion system development tool and performance optimizer. Pro-Motion is a sophisticated, easy-to-use program which allows all motion parameters to be set and/or viewed, and allows all features to be exercised.

C-Motion Engine Development Tools Manual

Describes the C-Motion Engine Development Tools that allow user application code to be created and compiled on a host PC, then downloaded, executed and monitored on a CME device C-Motion Engine module.

PMD Resource Access Protocol Programmer's Reference

Describes the PMD Resource access Protocol (PRP) used for communication between the host and a PRP device, the software interfaces and binary protocols, the procedures and data types used for programs, software libraries and C-Motion library code.

Table of Contents

1. Introduction 9
1.1 ION Digital Drive Overview 9
1.2 Features and Functions 10

2. Installation 11
2.1 ION/CME Model Numbering 11
2.2 ION/CME Developer's Kits 12
2.3 Required Hardware 12
2.4 ION/CME Hardware Configuration and Mounting 13
2.5 Connector Pinouts and Wiring 14
2.6 Software Installation 28
2.7 Communications Configuration 28
2.8 Applying Power 29
2.9 Status LEDs 30
2.10 First-Time System Verification 31

3. Operation 39
3.1 ION/CME Block Diagram 39
3.2 Communication Port 40
3.3 PWM Power Stage 40
3.4 DC Bus 43
3.5 Trace Buffer 44
3.6 Operational and Fault Modes 45

4. ION/CME Control 47
4.1 Communication Protocols 47
4.2 ION/CME Access Basics 48
4.3 Magellan Motion Processor Functions 48
4.4 General Purpose Digital I/O 50
4.5 Analog Input 52
4.6 C-Motion Engine Functions 54
4.7 Communications Functions 57
4.8 ION/CME Reset 59
4.9 Non-volatile Memory 60
4.10 Setting Module Defaults 61
4.11 ION/CME Command Summary 62

5. Options and Accessories 63
5.1 Stub Cable Set 63
5.2 Development Kit Cable and Plug Specifications 64
5.3 Optional Heat Sink 67
5.4 Optional DIN Rail Adapter 68

6. Electrical Signal Interfacing 69
6.1 Motor Feedback 69
6.2 Auxiliary Position Input 71
6.3 Limit and Home Inputs 72
6.4 Position Capture Sources 72
6.5 AxisIn and AxisOut Signals 73

6.6 /Enable and FaultOut Signals 74
6.7 General Purpose Digital Inputs and Outputs 76
6.8 Analog Inputs 77

7. ION/CME Specifications 79
7.1 ION/CME Drive Ratings 79
7.2 ION/CME Controller Performance 80
7.3 ION/CME Electrical 81
7.4 ION/CME Protection Circuits 83
7.5 ION/CME Connectors and Pinouts 83
7.6 ION/CME Mechanical 86
7.7 ION/CME Environmental 87
7.8 ION/CME Safety and Compliance 87
7.9 ION/CME Thermal Operating Curves 87

Index 89

List of Figures

Figure 2-1: Connector locator 14
Figure 2-2: Typical power wiring 16
Figure 2-3: Typical motor wiring 17
Figure 2-4: Recommended feedback wiring 19
Figure 2-5: Recommended auxiliary encoder wiring 20
Figure 2-6: Single encoder mode connections 21
Figure 2-7: Dual encoder mode connections 22
Figure 2-8: Pulse & direction input connections 23
Figure 2-9: Typical I/O wiring 24
Figure 2-10: Indexer I/O wiring 25
Figure 2-11: RS232/485 wiring 27
Figure 2-12: Serial port connection 28
Figure 3-1: ION/CME block diagram 39
Figure 3-2: Simplified serial transceiver diagram 40
Figure 4-1: ION/CME block diagram 49
Figure 4-2: Analog inputs simplified diagrams 53
Figure 4-3: C-Motion Engine architecture 54
Figure 5-1: ION/CME heat sink 67
Figure 5-2: ION/CME with heat sink attached 67
Figure 5-3: Attaching the optional DIN rail adapter 68
Figure 5-4: ION mounted on DIN rail 68
Figure 6-1: Main encoder input circuits 69
Figure 6-2: Encoder phasing diagram 70
Figure 6-3: Hall input circuits 70
Figure 6-4: Auxiliary encoder input circuits 71
Figure 6-5: Limit and Home input circuits 72
Figure 6-6: High Speed Capture circuit 73
Figure 6-7: AxisIn circuit 73
Figure 6-8: AxisOut circuit 74
Figure 6-9: /Enable input circuit 75
Figure 6-10: FaultOut circuit 75
Figure 6-11: Digital inputs circuit 76
Figure 6-12: Digital outputs circuit 77
Figure 6-13: Digital I/O circuit 77
Figure 6-14: Analog inputs simplified diagram 78
Figure 7-1: ION/CME dimensions 86
Figure 7-2: ION/CME derating curve for DC brush module 87
Figure 7-3: ION/CME derating curves for brushless DC module 88
Figure 7-4: ION/CME derating curves for step motor module 88

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1. Introduction

In This Chapter

- ION Digital Drive Overview
- Features and Functions

1.1 ION Digital Drive Overview

The ION Digital Drives are a family of single-axis motion controllers with integrated power electronics and network communications. Various models are available to drive DC brush, brushless DC, and step motors. In addition, two overall power levels are available: The ION 500, providing up to 500 watts of power output, and the ION 3000, providing up to 3,000 watts of power output.

ION digital drives are based on PMD's Magellan Motion Processor technology and perform profile generation, encoder position feedback, position servo compensation, step motor stall detection, brushless DC motor commutation, microstep generation, and digital current/torque control. Network communications options include Ethernet, CANbus, RS485, and RS232.

All members of the ION family have integrated, high-power drive stages which fully protect from overcurrent, undervoltage, overvoltage, overtemperature, and short-circuit faults. In addition to extensive motion I/O capability, ION also features Auxiliary Encoder inputs and dedicated Enable input and Fault output safety interlocks. ION's flexible mounting configurations include both a vertical and a horizontal option, while ION 500 offers an additional DIN rail mount option with optional heat sink.

In addition to various configurations of motor type and power level, the ION family is split into three functional versions. The 'standard' IONs (no additional 'slash' specifier) provide network connectivity, profile generation, and torque control. The '/CME' IONs provide the additional capability of an internal C-Motion Engine, allowing user code to reside inside the ION. In addition, this version provides an indexer connector for enhanced connectivity. The '/B' ION version provides ±10V input and torque control of the motor, along with pulse & direction positioning control.

This manual describes the features and functions of the ION/CME Digital Drives. For additional information on the standard versions of the ION, refer to the *ION Digital Drive User's Manual*. For the /B versions, refer to the *ION/B Digital Drive User's Manual*.

For more information on the Magellan Motion Processor and its software command set, refer to the *Magellan Motion Processor User's Guide* and the *Magellan Motion Processor Programmer's Command Reference*.

1.2 Features and Functions

At the heart of ION/CME are the Magellan Motion Processor and the C-Motion Engine (CME). This member of the ION family provides an extensive list of control functions, including:

- Host communications over Ethernet, RS232, or RS485
- Ability to download and execute user application code in the ION
- 256 KB of programmable user code space
- Code execution rate up to 96 MIPS (million instructions per second)
- Advanced C-Motion Engine development tools
- Trajectory generation, including trapezoidal and S-curve point-to-point profiling, velocity contouring, and electronic gearing modes
- Advanced PID position loop with integration limit, derivative sample time, velocity and acceleration feedforward, output bias, dual biquad filters, and support for dual encoder feedback
- Indexer connector providing additional digital I/O and 16-bit analog input
- Two encoder input channels capable of up to 10 Mcounts per second
- Sinusoidal and six-step (Hall) brushless DC commutation modes
- Microstepping outputs with up to 256 microsteps per step
- Digital current loop with choice of standard A/B or Field Oriented Control (FOC) for both brushless DC and step motors
- Single phase current loop for DC brush motors
- Pulse and direction input
- High-efficiency MOSFET power stages with versions for single-phase brush DC motors, two-phase step motors, and three-phase brushless DC motors
- I^2t current foldback limiting
- Selectable 20 kHz and 40 kHz PWM frequencies to support a broad range of motor inductance
- Overcurrent, short circuit, overvoltage, undervoltage, and overtemperature protection
- Single supply operation. An onboard DC/DC converter supplies all internal circuitry and also provides 5V for encoders and other external I/O.
- Enable input and Fault output safety interlock
- Differential or single-ended encoder input buffers for all encoder channels
- Signal conditioning buffers and analog filters on all I/O signals

ION comes packaged in a rugged enclosure with flexible mounting options and reliable signal and power connectors. ION is fully RoHS compliant and CE marked.

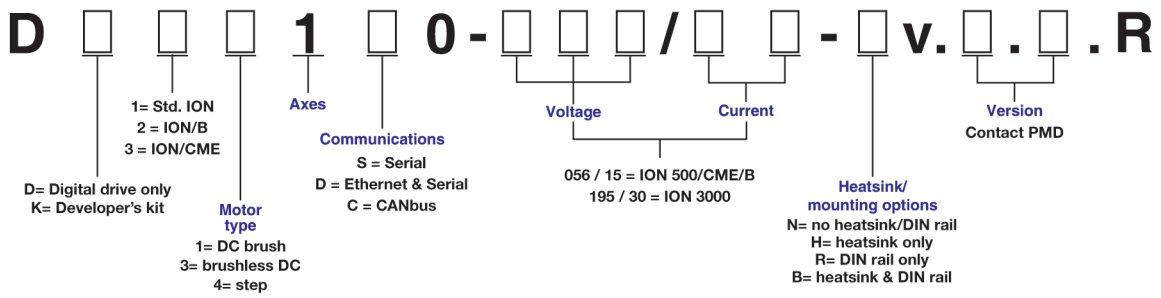
2. Installation

2

In This Chapter

- ION/CME Model Numbering
- ION/CME Developer's Kits
- Required Hardware
- ION/CME Hardware Configuration and Mounting
- Connector Pinouts and Wiring
- Software Installation
- Communications Configuration
- Applying Power
- Status LEDs
- First-Time System Verification

2.1 ION/CME Model Numbering



The ION/CME family consists of versions to drive three motor types (DC brush, brushless DC, and step) with the choice of two communications modes: Ethernet or Serial (both RS232 and RS485). The units can be provided with or without heat sink and DIN rail mounting options. One power level is provided, which can drive up to 500W output.

2.1.1 ION/CME Part Numbers

The following table shows the base part number configurations for the ION/CME.

Model Number	Motor Type	Communications Port
DD331D0-056/15	Brushless DC	Ethernet & Serial
DD311D0-056/15	DC Brush	Ethernet & Serial
DD341D0-056/15	Step Motor	Ethernet & Serial

2.2 ION/CME Developer's Kits

To facilitate initial system development and integration, ION/CME is offered in a Developer's Kit version. A model number beginning with DK instead of DD specifies the Developer's Kit version.

The following software and accessory products are included in the ION Developer's Kit:

- Pro-Motion CD and User's Guide
- C-Motion Engine Software Developer's Kit, including:

  A complete toolset for the creation of user-specific applications running on ION/CME or host

  An open-source compiler and motion-control C libraries

  PDF files of all documentation
- C-Motion and VB-Motion CD including PDFs of all ION documentation
- Communications cables with adapters (Ethernet and Serial)
- Stub cable set – a complete set of cables with matching ION/CME connectors on one end and flying leads on the other
- For more information on these accessory products, refer to Chapter 5, Options and Accessories.

2.2.1 Developer's Kit Model Numbers

Model Number	Motor Type	Communications Port
DK331D0-056/15	Brushless DC	Ethernet & Serial
DK311D0-056/15	DC Brush	Ethernet & Serial
DK341D0-056/15	Step Motor	Ethernet & Serial

2.3 Required Hardware

To install an ION/CME Digital Drive, the following hardware is required:

- A host controller. The recommended PC platform is an Intel (or compatible) processor, Pentium or better, one available COM port, 200MB of available disk space and a CD-ROM drive. The supported PC operating systems are Windows XP, Vista, and Windows 7.
- An Ethernet port
- For RS232 or RS485 communications, a PCI card, PCMCIA card, or USB adapter supporting the desired standard connected to the PC
- Mounting screws to attach the ION module to your cabinet or system
- Properly sized DC bus power supply
- Step, DC brush, or brushless DC motor, with encoder as required by the application
- Cables. Either the stub cable set that comes with ION/CME Developer's Kits or custom cables designed for the system.
- Limit switches and other I/O as required for the application

2.4 ION/CME Hardware Configuration and Mounting

There are no user-settable switches, jumpers, or potentiometers within the ION/CME module. All hardware features are configurable from the host computer via the communications port.

Mount the module firmly in the desired orientation with adequate space to allow it to be effectively cooled. ION/CME is designed to allow maximum mounting flexibility.

2.4.1 ION/CME Mounting Options

Cooling Method	Recommended Orientation	Recommended Mounting Surface	Mounting Method
Coldplate	Any	Either	Horizontal - 4 screws Vertical - 2 screws
Convection	Vertical	Back (small side)	2 screws or DIN rail adapter
Convection with Optional Heat Sink	Vertical	Back (small side)	2 screws or DIN rail adapter
Forced Air	Any	Either	2 or 4 screws, or DIN rail adapter
Forced Air with Optional Heat Sink	Any	Back (small side)	Horizontal - 4 screws Vertical - 2 screws

To minimize electrical noise problems, the metal base of the ION/CME enclosure should be grounded. This is usually accomplished automatically when the module is mounted to a metal part of a grounded system. When mounted to a DIN rail using the optional DIN rail adapter or when mounted to a non-conductive or non-grounded surface, one of the free mounting holes can be used to attach a grounding wire. Note that to make proper electrical contact to the ION's mounting holes, it may be necessary to scrape off the ION's powder coating in this area. It is the responsibility of the user to ensure proper electrical conduction to the metal base of the ION/CME enclosure.

Refer to Section 7.6, ION/CME Mechanical for information on mounting dimensions and mounting hole sizes for the ION/CME. Refer to Figure 2-1 for cable connection locations.

2.5 Connector Pinouts and Wiring

2.5.1 ION/CME Connector Locator

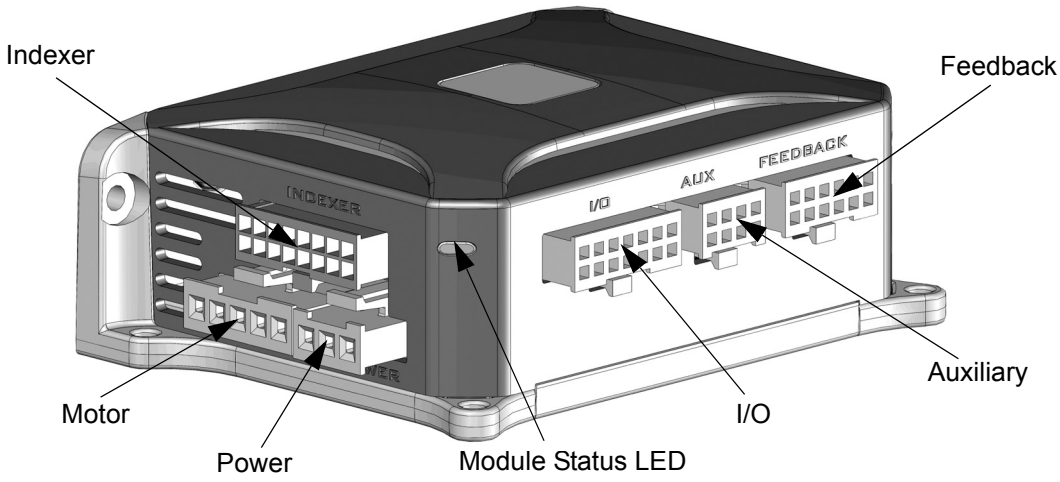
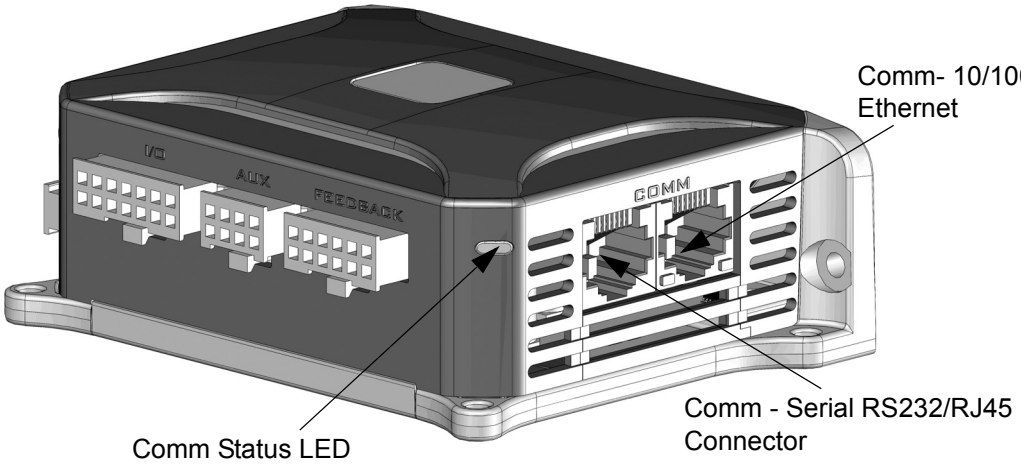


Figure 2-1: Connector locator

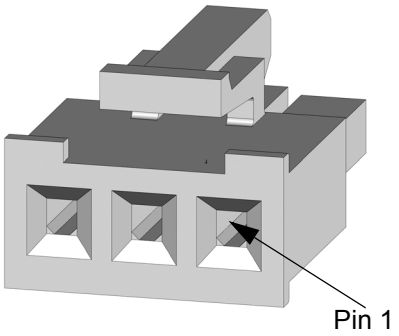


2.5.2 Motor/Module Type Quick Reference

The following table summarizes the recommended connections for the various motor types and the corresponding ION/CME modules:

Module Type	Connector	Required Signals	Optional Signals
All	Power	+HV, Pwr_Gnd	AuxV
DC brush	Motor	Motor+, Motor-, Case/Shield	
	Feedback	Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, Shield	IO_5V
Brushless DC	Motor	Motor A, Motor B, Motor C, Case/Shield	
	Feedback	Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, Shield	Commutation (Hall A, Hall B, Hall C), IO_5V
Microstepping	Motor	Motor A+, Motor A-, Motor B+, Motor B-, Case/Shield	
	Feedback		Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, IO_5V, Shield
All	Auxiliary		Auxiliary encoder (Quad A+, Quad A-, Quad B+, Quad B-), IO_Gnd, IO_5V, Shield, Pulse+, Pulse-, Direction+, Direction-
All	I/O	/Enable, IO_Gnd	+Limit, -Limit, Home, High Speed Capture, AxisIn, AxisOut, FaultOut, IO_5V, Shield
Serial	Comm	RS232: Tx, Rx, IO_Gnd, Select	
		RS485: Select, Tx+, Tx-, Rx+, Rx-, IO_Gnd	
Ethernet	Comm	Select,Tx+, Tx-, Rx+, Rx-	
All	Indexer		Shield, IO_Gnd, IO_5V, AnalogIn-, AnalogIn+, DigitalOut1, DigitalOut2, DigitalIn1, DigitalIn2, DigitalIn3, DigitalIn4, DigitalIO5, DigitalIO6, DigitalIO7, DigitalIO8

2.5.3 Power Connector



Pin	Signal
1	+HV
2	AuxV
3	Pwr_Gnd

This connector supplies the main DC power to the ION/CME module. ION/CMEs should be wired with 16 AWG wire. ION/CME has a built-in DC/DC converter that derives all required internal voltages from the main DC bus. A separate logic supply is not required. This DC/DC converter also provides IO_5V for powering encoders, limit switches, and other system I/O.

As an additional safety feature, ION/CME provides a separate Auxiliary Voltage (**AuxV**) input that can be used to power just this DC/DC converter without powering the main DC bus and the output stage. When the **AuxV** is not connected, power for the DC/DC converter comes from the main **+HV** input.

A (transformer) isolated power supply should be used for powering ION/CME. The return of this power supply should be grounded. The size of the power supply has to meet the load requirement. If a regulated power supply is used, care should be taken to make sure the power supply can sustain the regenerated power. If a diode is used, the input capacitor should be able to hold the regenerated power without triggering ION/CME into overvoltage protection.

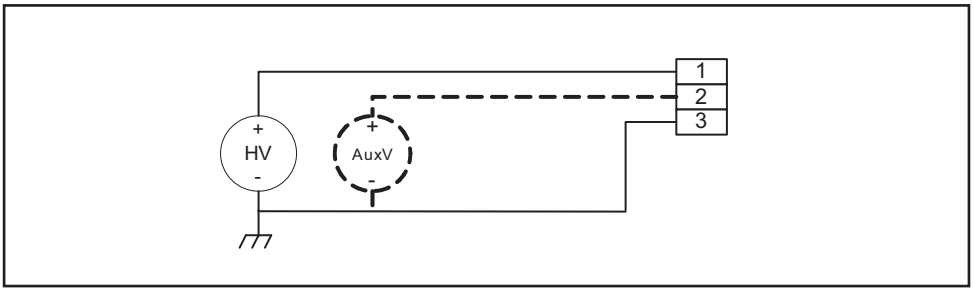
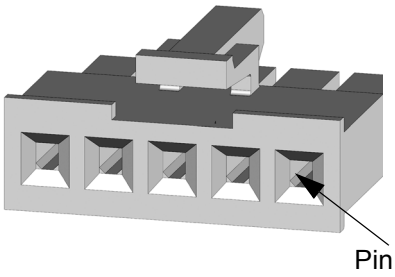


Figure 2-2: Typical power wiring

Pin 3 of the power connector (Pwr_Gnd) should be connected to earth ground as shown in Figure 2-2.

2.5.4 Motor Connector



Pin	DC Brush	Brushless DC	Step
1	Motor+	Motor A (U)	Motor A+
2	No connect	Motor B (V)	Motor A-
3	Motor-	Motor C (W)	Motor B+
4	No connect	No connect	Motor B-
5	Case/Shield	Case/Shield	Case/Shield

This connector is used to connect the ION module to the motor. Depending on the type of motor being driven, up to five connections are required. It should be wired with 16 AWG wire to minimize voltage drops between the ION drive and the motor. The use of shielded cable is recommended to minimize noise (Figure 2-3).

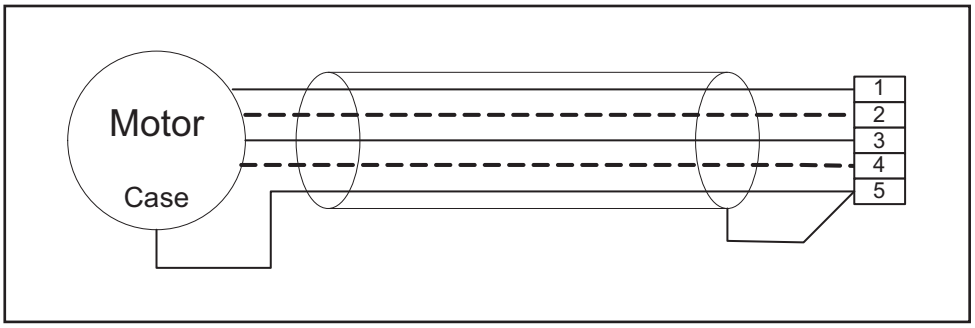
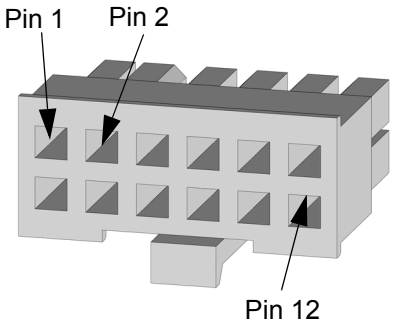


Figure 2-3: Typical motor wiring

For best performance, the case wire should run within the cable shield. If the motor does not come with a case wire or other dedicated case connection, a lug under a motor mounting screw can be used.

The shield drain wire should be connected at the ION module connector end only.

2.5.5 Feedback Connector



Pin	DC Brush	Brushless DC	Step
1	Shield	Shield	Shield
2	IO_Gnd	IO_Gnd	IO_Gnd
3	IO_5V	IO_5V	IO_5V
4	Not used	Hall A	Not used
5	Not used	Hall B	Not used
6	Not used	Hall C	Not used
7	Quad A+	Quad A+	Quad A+
8	Quad A-	Quad A-	Quad A-
9	Quad B+	Quad B+	Quad B+
10	Quad B-	Quad B-	Quad B-
11	Index+	Index+	Index+
12	Index-	Index-	Index-

This connector is used to wire the signals from the main feedback encoder to the ION module. For brushless DC motors, it also connects the Hall Effect signals typically used to commutate the motor. The Halls are not used with DC brush or step motors.

ION directly supports quadrature encoders with either single-ended or differential outputs. IO_5V and IO_Gnd are provided to power the encoder and Hall Effect transducers. This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG shielded cable is recommended. For differential encoders, twisted-pair cable should be used. Figure 2-4 shows recommended feedback wiring.

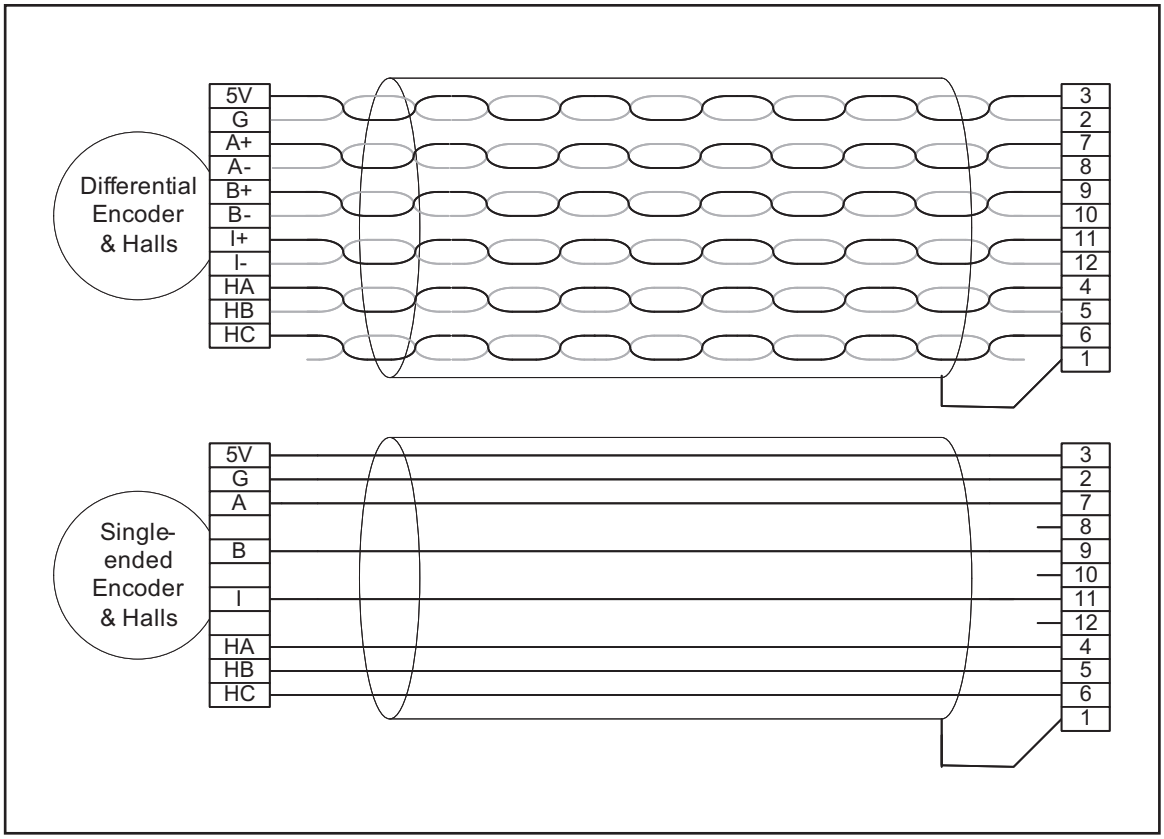
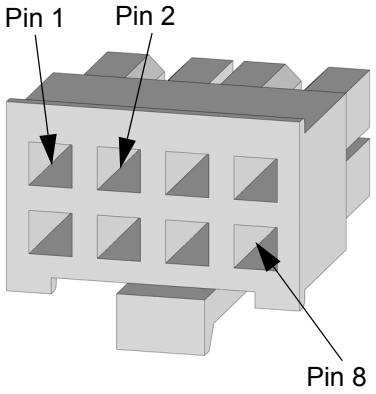


Figure 2-4: Recommended feedback wiring

The shield drain wire should be connected at the ION module connector end only.

2.5.6 Auxiliary Connector



Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	No connect
5	Quad A+ or Pulse+
6	Quad A- or Pulse-
7	Quad B+ or Direction+
8	Quad B- or Direction-

ION provides a second quadrature encoder port for use as a master in master-slave and electronic gearing applications or a pulse and direction input for use in electronic gear applications. As on the main encoder port, ION supports both single-ended and differential signal input. This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG twisted-pair shielded cable is recommended (Figure 2-5).

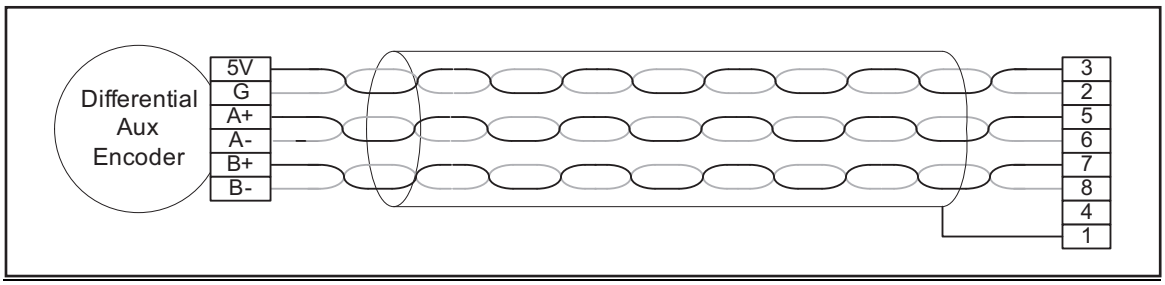


Figure 2-5: Recommended auxiliary encoder wiring

The shield drain wire should be connected at the ION module connector end only.

2.5.6.1 Single Encoder Connections Summary

ION can be connected to feedback encoders in both a single and a dual encoder configuration. Dual encoder input may be useful for general purpose auxiliary encoder position feedback, master/slave electronic gear operation, or dual loop servo filter operation. See the *Magellan Motion Processor User's Guide* for more information on these control modes.

Figure 2-6 and the table that follows it summarize the connections for a single encoder

.

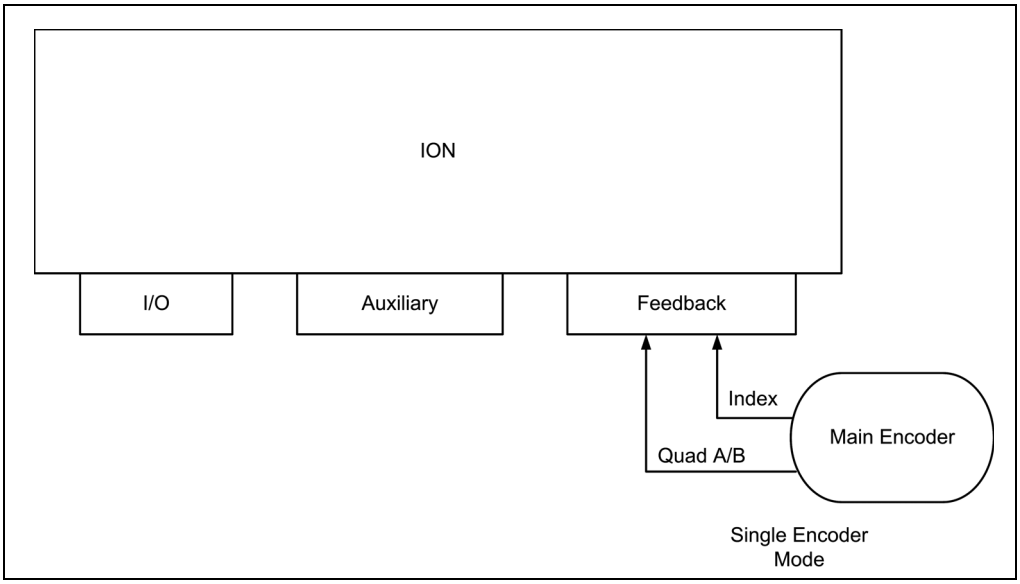


Figure 2-6: Single encoder mode connections

Connection from Encoder	ION Connector	Pin	ION Pin
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
Hall A*	Feedback	4	Hall A
Hall B*	Feedback	5	Hall B
Hall C*	Feedback	6	Hall C

*Brushless DC motors only

2.5.6.2 Dual Encoder Connections Summary

In a two-encoder connection, one encoder measures the load position and is the primary encoder. The second (auxiliary) encoder is located on the motor shaft, measures the motor position, and is used for stabilization. Figure 2-7 and the table that follows show how to connect two encoders to the ION.

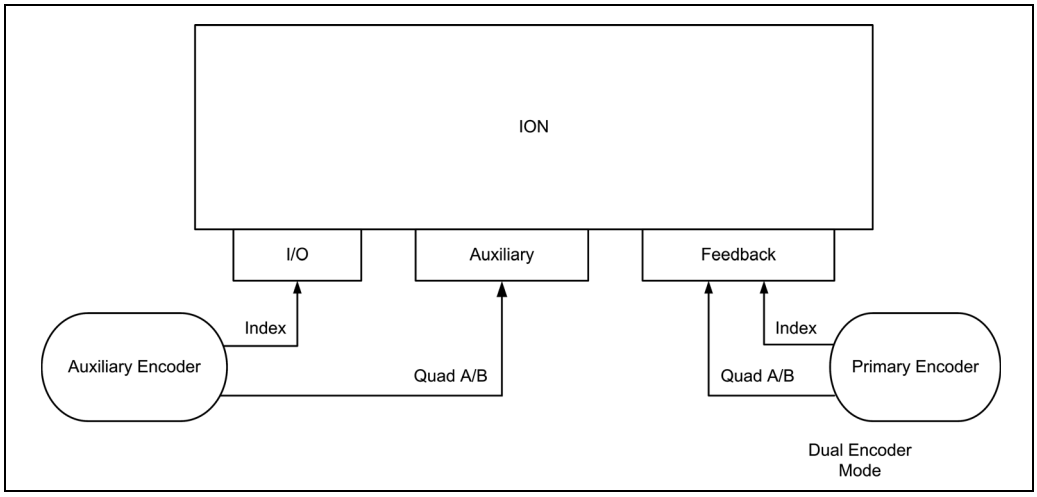


Figure 2-7: Dual encoder mode connections

Connection from Encoder	ION Connector	Pin #	ION Pin
From primary encoder			
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
From auxiliary encoder			
Quadrature A+	Auxiliary	5	Quad A+
Quadrature A-	Auxiliary	6	Quad A-
Quadrature B+	Auxiliary	7	Quad B+
Quadrature B-	Auxiliary	8	Quad B-
Index+*	I/O	11	High Speed Capture
Hall A**	Feedback	4	Hall A
Hall B**	Feedback	5	Hall B
Hall C**	Feedback	6	Hall C

* For brushless DC motors, an Index signal from the auxiliary encoder is recommended when Hall sensors are not available. For all other configurations, use of the ION's High Speed Capture signal input is optional.

** Brushless DC motors only

2.5.6.3 Pulse & Direction Input Connections Summary

With ION/CME, it is possible to command the position of the drive using pulse & direction input signals. Refer to Figure 2-8.This mode can be used with all motor types, DC Brush, Brushless DC, and step motor, and allows the ION to interface to any general purpose motion controller that outputs pulse & direction position information.

Operation of the ION in pulse & direction input mode is software selectable. To enter this mode the encoder source for axis #2 should be set to pulse & direction, and the profile mode should be set to electronic gear. See the *Magellan Motion Processor User's Guide* for more information.

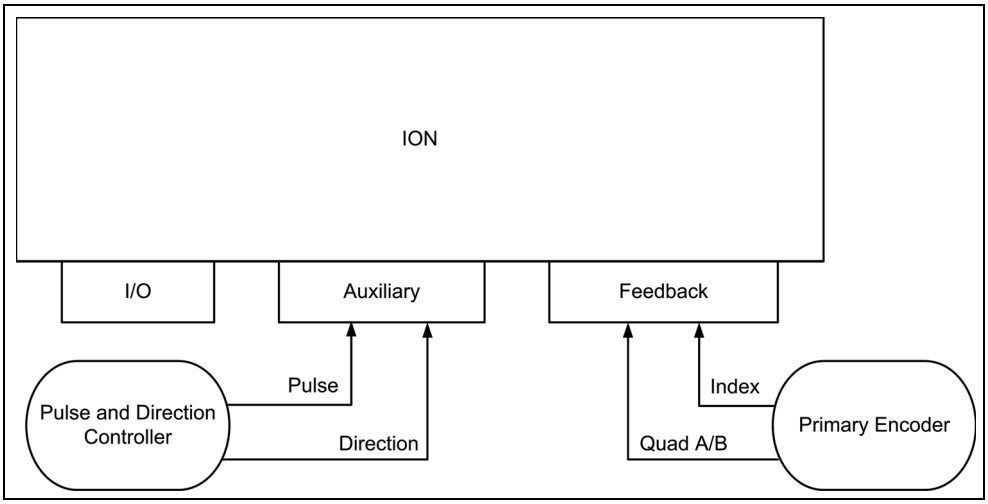


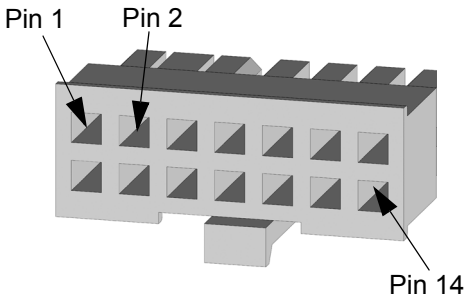
Figure 2-8: Pulse & direction input connections

To connect to the ION in this configuration, use the following connections:

Connection from Encoder	ION Connector	Pin #	ION Pin
Pulse & Direction input			
Pulse+	Auxiliary	5	Pulse+
Pulse-	Auxiliary	6	Pulse-
Direction+	Auxiliary	7	Direction+
Direction-	Auxiliary	8	Direction-
Encoder input (optional if controlling step motor)			
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
Hall A*	Feedback	4	Hall A
Hall B*	Feedback	5	Hall B
Hall C*	Feedback	6	Hall C

* Brushless DC motors only

2.5.7 I/O Connector



Pin	Signal	Pin	Signal
1	Shield	8	+Limit
2	IO_Gnd	9	-Limit
3	IO_5V	10	Home
4	IO_Gnd	11	High Speed Capture
5	IO_5V	12	AxisIn
6	IO_Gnd	13	AxisOut
7	FaultOut	14	/Enable

This connector is used to wire motion-specific I/O signals such as overtravel limits, home reference, and high speed capture input as well as the general-purpose ***AxisIn*** and ***AxisOut*** signals. It also has pins for the master ***/Enable*** input and ***FaultOut*** signals. Numerous IO_5V and IO_Gnd connections are provided to simplify wiring.

This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG shielded cable is recommended. Figure 2-9 shows typical I/O wiring.

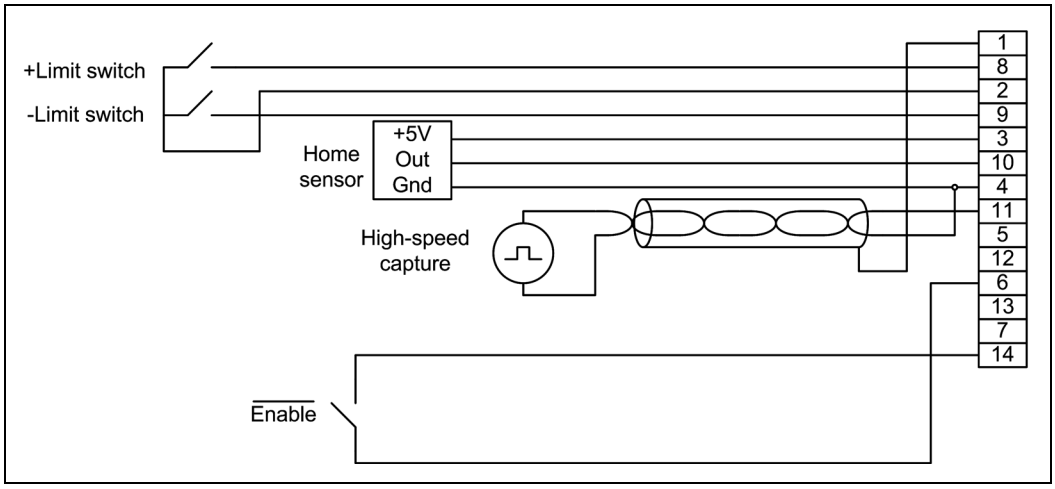
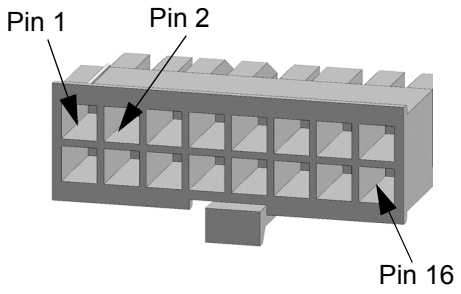


Figure 2-9: Typical I/O wiring

2.5.8 Indexer Connector



Pin	Signal	Pin	Signal
1	Shield	9	DigitalIn1
2	IO_Gnd	10	DigitalIn2
3	IO_5V	11	DigitalIn3
4	AnalogIn-	12	DigitalIn4
5	AnalogIn+	13	DigitalIO5
6	IO_Gnd	14	DigitalIO6
7	DigitalOut1	15	DigitalIO7
8	DigitalOut2	16	DigitalIO8

The Indexer connector is used to access general purpose I/O signals and a differential input analog signal. The analog input wire pair should be run as a twisted-pair for noise minimization. A general purpose 5V power connection is also provided on the Indexer connector. See Figure 2-10.

This connector supports wire gauges from 20 to 30, depending on the crimp terminal used. Wiring with 22 AWG shielded cable is recommended. The shielding on the cable should connect to Pin 1 of the Indexer connector.

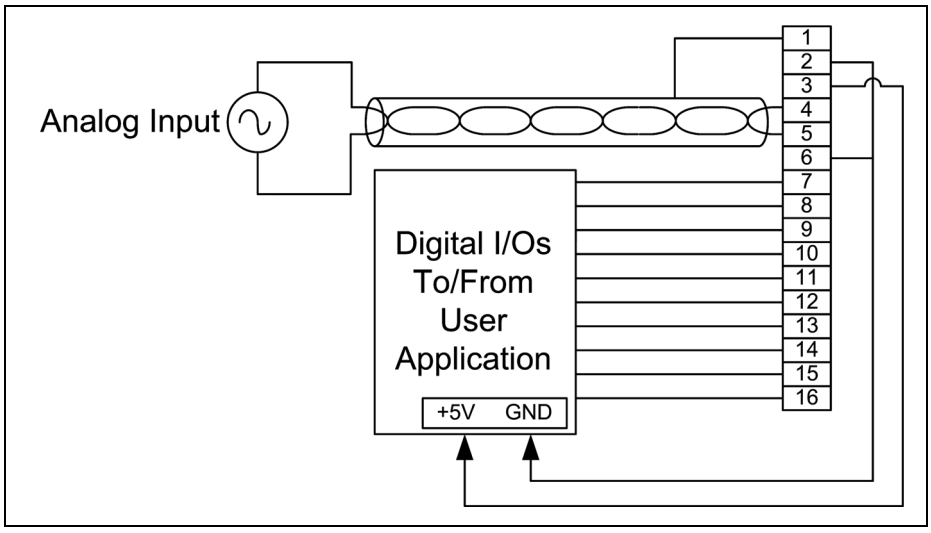
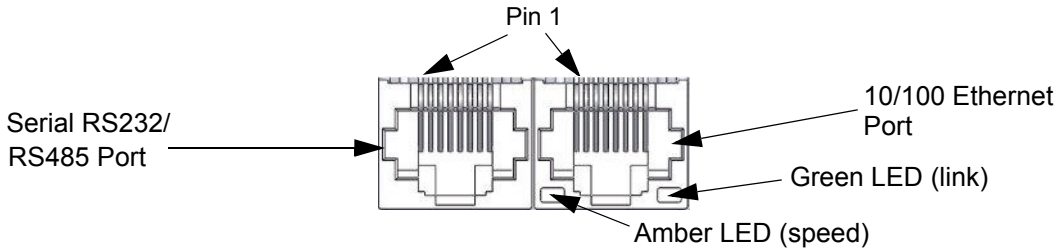


Figure 2-10: Indexer I/O wiring

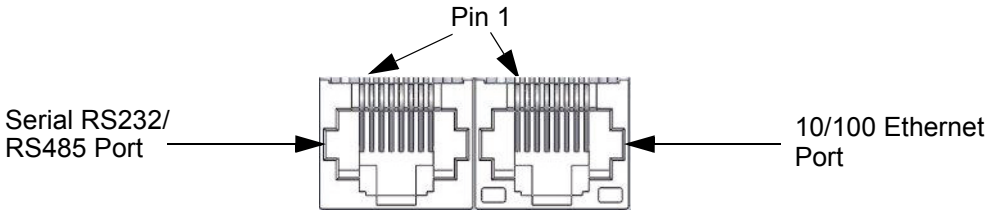
2.5.9 Ethernet Connector



Pin	Signal
1	Tx+
2	Tx-
3	Rx+
4	Unused
5	Unused
6	Rx-
7	Unused
8	Unused

ION/CME has a standard, 8-pin RJ45 connector for Ethernet connection. Standard UTP (unshielded twisted pair) CAT5 Ethernet cabling can be used in most applications. For added noise immunity, use shielded cable.

2.5.10 Serial RS232/485 Connector



An RJ45-type connector provides serial connectivity on the Ethernet/Serial ION. This serial connector can support both RS232 and RS485. Pinouts for both of these serial protocols are provided in the table below:

Pin	RS232	RS485
1	Unused	Unused
2	Unused	Unused
3	Rx	Rx+
4	Unused	Tx+
5	Tx	Tx-
6	Unused	Rx-
7	IO_Gnd	IO_Gnd
8	Select = Float/High	Select = low

For RS232, pin 8 must be left floating. For RS485, pin 8 must be connected to IO_Gnd. For connecting to an RS232 serial port on a host machine, an adapter is needed to interface between DB9 and RJ45 connectors (PMD P/N Adapter-1010-01).

Figure 2-11 shows RS232 and RS485 wiring.

ION/CME does not have built-in termination for RS485. If a network application requires termination at the ION/CME serial connector, resistors must be added in the network wiring.

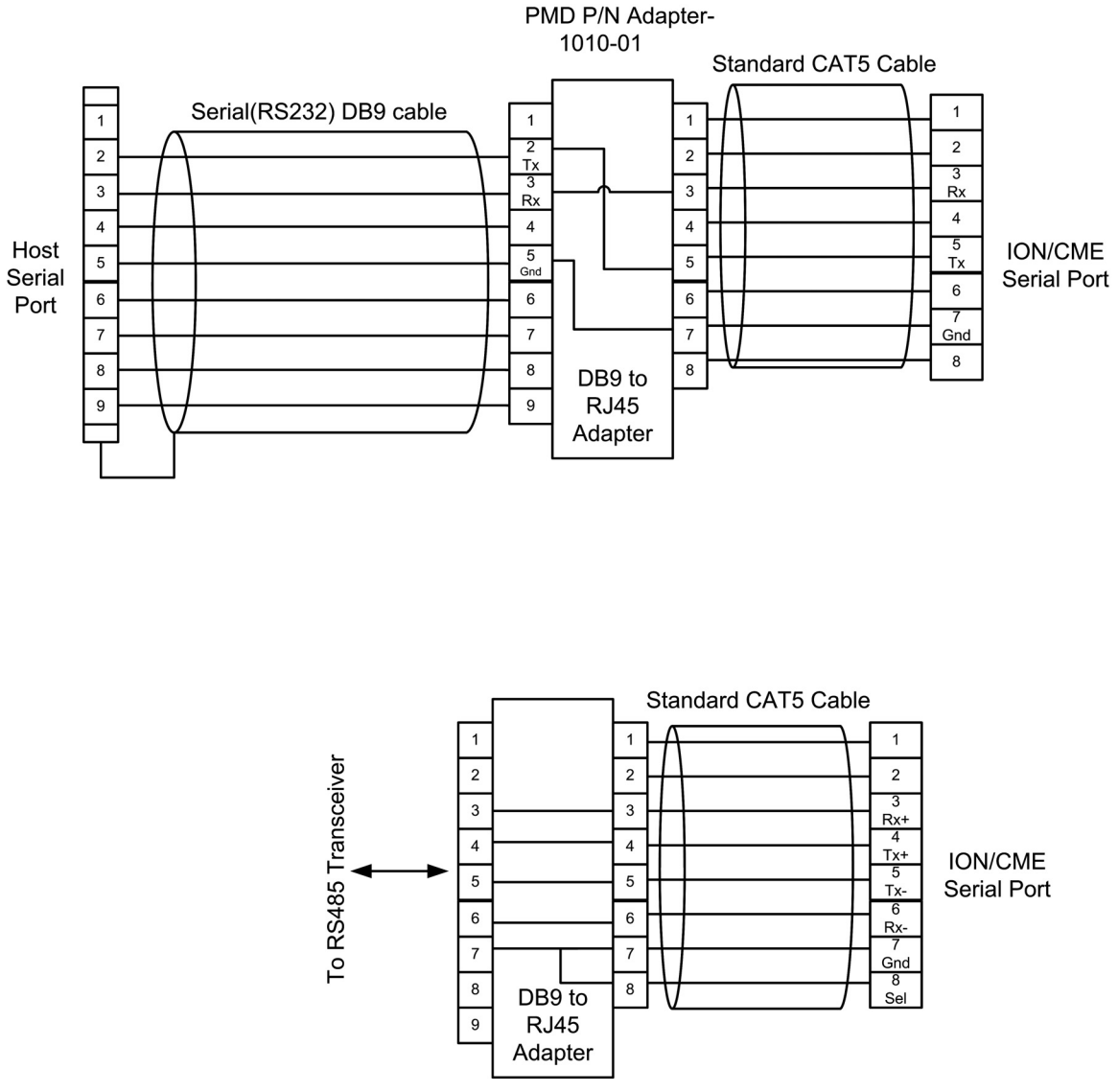


Figure 2-11: RS232/485 wiring

For RS232, pin 8 must be left floating. For RS485, pin 8 must be connected to IO_Gound.

2.6 Software Installation

Each ION/CME developer's kit provides several major software packages for motion system development:

- Pro-Motion, an interactive Windows-based exerciser and software development tool.
- C-Motion, a C-language library that allows the developer to create motion applications using the C programming language.
- C-Motion Engine Development Tools, a set of development resources that allows the developer to create, download, and monitor programs loaded in the ION/CME C-Motion Engine.

Additional information on each of these software packages is provided as follows:

Locate the Pro-Motion CD and install the Pro-Motion application on the host computer, following the instructions in the *Pro-Motion User's Guide*. This software will configure the module and fully exercise the features of the ION/CME Digital Drive.

PDF versions of this manual, the *Magellan Motion Processor User's Guide,* and the *Magellan Motion Processor Programmer's Command Reference* can be found on the CD included with the ION/CME developer's kit.

Adobe Acrobat Reader is required for viewing these files. If the Adobe Acrobat Reader is not installed on your computer, you may download it at no cost from http://www.adobe.com.

2.7 Communications Configuration

Depending on the communications port you plan to use with your ION, there may be some configuration steps required to communicate correctly between the host computer and the ION module.

2.7.1 Serial Communications

To communicate by RS232, connect ION/CME to the PC using the straight-through serial cable provided with the Developer's Kit. For more information, refer to Figure 2-12. If the PC does not have a serial port, use a USB-to-serial converter and note the COM port number that the converter installed as using the Device Manager in Windows. Select this COM port in Pro-Motion's Connect dialog.

The following RS232/485 values are pre-programmed into non-volatile memory at the factory. You can change the operational values using Pro-Motion after communications at this default rate has been established. Note that the new parameters will take effect at the next ION powerup.

RS232/485 default values: 57.6 kbaud, no parity, 1 stop bit and multi-drop (networking) mode disabled.

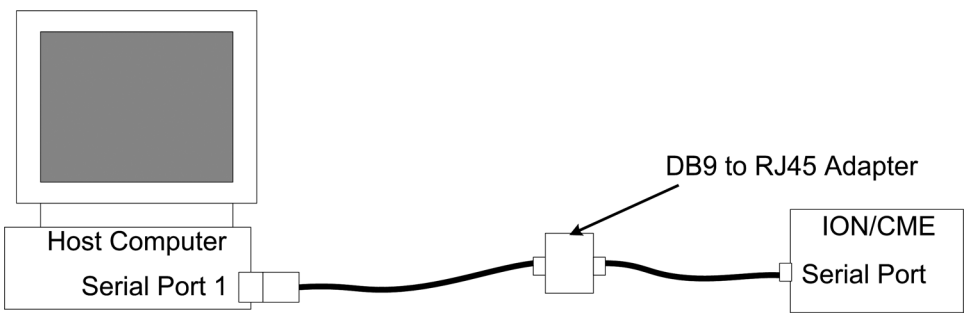


Figure 2-12: Serial port connection

First-time communication with an ION cannot be accomplished using RS485 half-duplex. To configure an ION for RS485 half-duplex (multi-drop), use either RS232 or RS485 (point-to-point).

Changing the state of the Select pin on the fly is not recommended. Doing so will change the hardware configuration without changing the active set of communication parameters and will most likely result in loss of communications.

2.7.2 Ethernet Communications

The ION/CME Ethernet port supports standard 10/100 Ethernet connectivity.

To communicate by Ethernet, a setup procedure must be executed which first uses the serial port to communicate with the ION/CME and configure the Ethernet port for subsequent communications.

To accomplish this, use the DK-provided serial and Ethernet cables and connect the ION/CME to your PC as shown in Figure 2-12. If your computer does not have a dedicated serial port, use a standard USB-to-serial converter.

The Ethernet connection will not be made until serial communications are established. See Section 2.10.2, Changing the Ethernet Parameters of the ION for detailed instructions on when to physically make the Ethernet connection. When Ethernet is ready to connect, use PMD's Cable-RJ45-02-R, and plug one end of the connector into the ION/CME Ethernet port, and the other end into a free Ethernet port on your network.

2.8 Applying Power

Do not apply power to the ION module until the motor and system wiring is complete and the ION module and motor are securely mounted. It is best to leave the motor disconnected from its load until after power is applied for the first time and correct operation is verified. The customer must not attempt to service or rewire an ION drive without first shutting down the drive and disconnecting it from its power source. Failure to follow this warning may result in fire, bodily harm, or damage to the product.

Upon first time power up, ION is in a reset condition. In this condition, no motor output will be applied and the motor will remain stationary. If the motor does move or jump, remove power from the module and re-check the wiring. If anomalous behavior is still observed, call PMD for application assistance. Complete PMD contact information is listed on the final page of this manual.

2.9 Status LEDs

ION has two bi-color LEDs to indicate the basic operational status of the module and the communications link. The location of these LEDs is shown in Figure 2-1.

2.9.1 Module Status LED

Upon powerup or reset, the module Status LED should either be solid green or blinking green, depending on the state of the */Enable* input. If enabled, the LED will be solid green.

The /Enable input is active low.

A Status LED of any other color indicates a fault or unusual condition that must be rectified before going further. See Section 2.10.2, Changing the Ethernet Parameters of the ION for complete information on ION Operational and Fault modes and the resulting color and blink rate of the Status LED.

2.9.2 Communications Status LED

The Comm Status LED indicates successful packets by blinking green and invalid packets or commands returning an error status by blinking red. A serious fault in the communications port is indicated with solid red. If the LED is solid red, check the cabling and then try cycling power and reconfiguring the communications configuration.

Note that this LED will not blink until communications occur. Therefore, the LED may not blink until further steps in the setup procedure occur.

2.10 First-Time System Verification

The first time system verification procedure summarized below has two overall goals. The first is to connect the ION with the PC so that they are communicating properly, and the second is to initialize the axis and bring it under stable control capable of making trajectory moves. While there are many additional capabilities that Pro-Motion and ION can provide, these steps will create a foundation for further, successful exploration and development.

Here is a summary of the steps used during first-time system verification. Each of these steps is described below in a separate manual section.

1. Initiate Pro-Motion and establish communication between the PC and the ION. For Serial communications, this is as simple as connecting the ION and running Pro-Motion. For Ethernet communications, this involves a few additional steps as detailed below.
2. Run Pro-Motion's Axis wizard for each axis of your system to initialize parameters such as encoder direction and safe servo parameters (if you are using a servo motor).
3. Execute a simple trajectory profile on each axis demonstrating that it is operating correctly and under stable control.

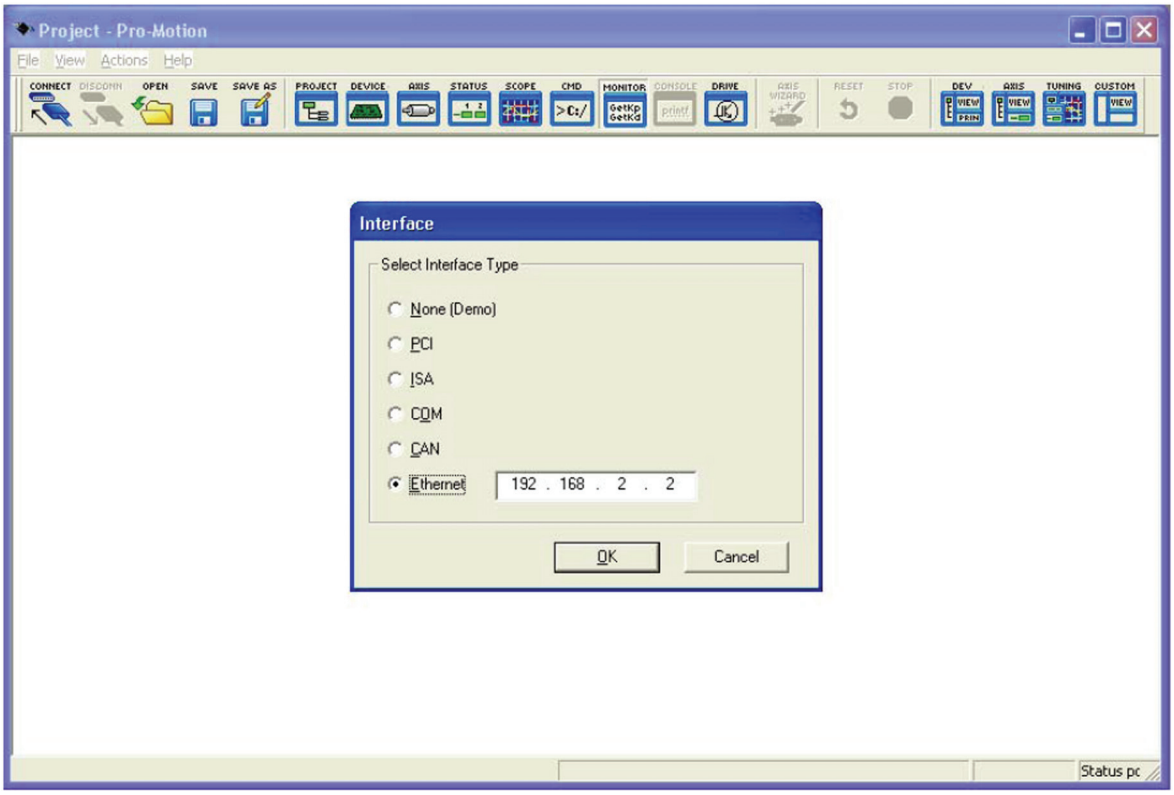
During this first-time system setup you may find it useful to refer to other PMD manuals including the *Pro-Motion User's Guide* for complete information on the Pro-Motion application. You may also want to refer to the *Magellan Motion Processor User's Guide* to familiarize yourself with operation of the Magellan Motion Processor, which lies at the heart of all ION Digital Drives.

2.10.1 Establishing Communications

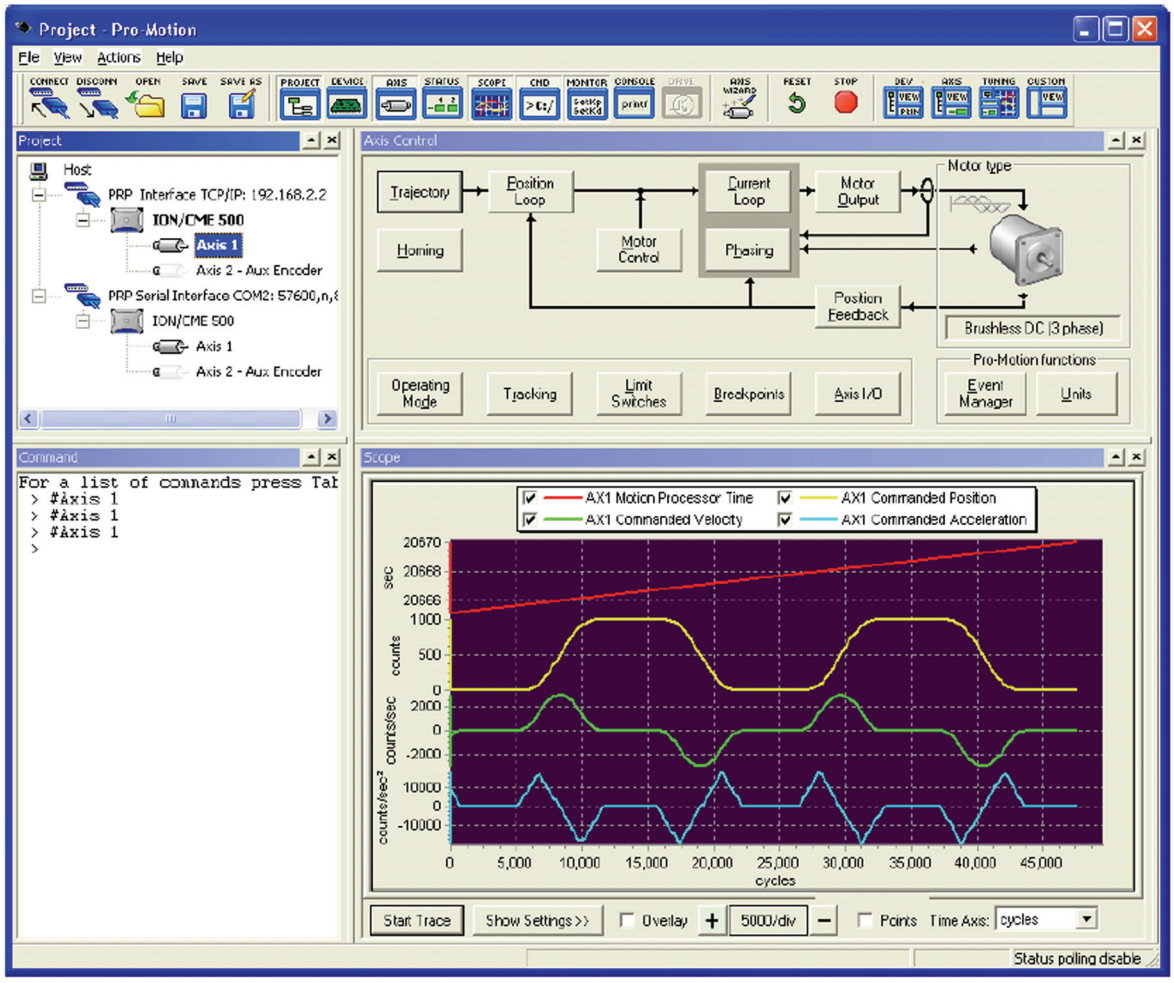
To establish communications:

1. Make sure the ION is powered and connected to the PC.
2. On the Start menu, click the Pro-Motion application. When Pro-Motion is launched you will be prompted with an Interface selection window. A typical screen view when first launching Pro-Motion appears below.
3. Click the Connect icon on the toolbar. Alternatively, on the File menu, select Connect.
4. Click Serial, then click OK. The Serial Port dialog box displays the active default communication values.
5. Click OK without changing any of these settings.

The purpose of the Interface dialog box is to indicate to Pro-Motion how your ION/CME is connected to the PC. It provides various selectable communication options such as serial and Ethernet.



If communication is correctly established, a set of object graphics loads into the Project window to the left, as shown in the following figure.



For example, for an ION, you see the ION name next to an icon of an ION, and below that you see two axes icons. Highlighting (single clicking) either the ION icon or the axis icon with the mouse is used to select specific modules or axes, and is useful later on in the first time system verification.

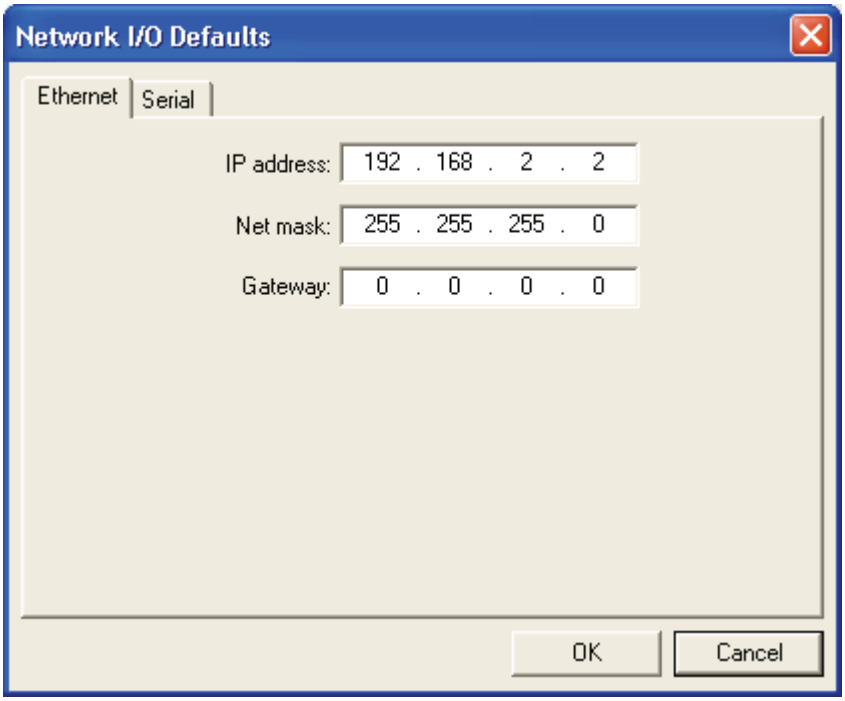
If communications are not correctly established, after approximately 10 seconds a dialog box appears indicating that a Communications Timeout Error has occurred. If this is the case, recheck your connections and repeat from step 1 above. If after repeated attempts a connection can still not be established, call PMD for assistance.

If you are using Serial, congratulations! Communication has been established and you are ready to proceed to the next step, described in Section 2.10.5, Initializing Motion Axes.

2.10.2 Changing the Ethernet Parameters of the ION

If you are using Ethernet communications, the next step is to change the Ethernet parameters as follows:

1. With serial communications functioning properly, click the Device toolbar button. The Device window appears.
2. Click Network I/O. The Network I/O Defaults dialog box appears.
3. Click the Ethernet tab. The Ethernet tab appears with data entry fields for the IP Address, the Net Mask, and the Gateway. This is shown below with default values visible.



4. Enter the IP Address in the corresponding data field as well as the net mask and gateway, if this is required for your network.

For a typical installation, you will not change the Net mask and Gateway default values, but you must specify a valid, unique, IP Address for the ION/CME to be located on your Ethernet network. If you are not sure what IP addresses are free and available for your Ethernet network, contact your system administrator.

5. Click OK to store as the power on default.
6. Click the Reset toolbar button. After the ION is reset, it uses the default parameters that you specified.
7. Connect the Ethernet cable. See Section 2.7, Communications Configuration for details.

The ION/CME is now ready for Ethernet communications.

2.10.3 Establishing Ethernet Communications

The ION's IP Address has now been set, but Pro-Motion does not know what IP address it should use for Ethernet communications to the ION.

To establish Ethernet communications:

1. Click the Connect toolbar button.
2. Select Ethernet, and then click OK.
3. Enter the same IP Address as was specified for Ethernet ION.
4. When complete, click OK.

If Ethernet communication is successful, an additional set of graphical icons representing your ION and axis will be loaded into the Project window.

If communication is not successful, after about 30 seconds, a Communications Timeout Error dialog box appears. If this happens, recheck your connections, and retry to establish Ethernet communications. See step 1 in Section 2.10.2, Changing the Ethernet Parameters of the ION for details.

When Ethernet communications are functioning properly, the final step is to disable serial communications.

2.10.4 Disconnecting Serial Communications

To disconnect serial communications:

1. Select the serial link version of the ION in the Project window.
2. Click the Disconnect toolbar button. A dialog box appears asking if you are sure you want to disconnect.
3. Click OK. You will notice that the serial ION icon and axes graphical icons in the Project box disappear, leaving only the Ethernet link icons for the ION and axis.

Congratulations! Ethernet communication is now up and running. You are ready to execute all Pro-Motion functions via Ethernet.

Multiple Pro-Motion users can connect to the same Ethernet ION. There are various situations where this may be useful. For example, one PC can function as a 'monitoring station' for a particular ION while another PC provides commands to that same unit. Be aware, however, that two or more users sending motion commands to the same motion controller can cause unexpected motion, and should be avoided.

When connecting your ION for use on an Ethernet network, be sure that the IP address provided for the ION does not conflict with the addresses of other users on the network. See Section 2.10.2, Changing the Ethernet Parameters of the ION for a description of changing the IP address.

2.10.5 Initializing Motion Axes

The next step to verify the correct operation of the system is to initialize the axis, thereby verifying correct encoder feedback connections (if an encoder is used), and other motion functions. All of this can be conveniently accomplished using Pro-Motion's Axis Wizard function. This versatile and easy to use tool initializes all supported motor types including step, DC Brush, and Brushless DC.

To operate the axis wizard:

1. Click to select the #1 axis icon in the Project window to the left of the screen.
2. With this icon highlighted, click the Axis Wizard toolbar button. The Axis Wizard initialization window appears.
3. Click Next and follow the Axis Wizard instructions for each page of the axis initialization process.

A typical Axis Wizard sequence takes 3-5 minutes. If you have specific questions about the Axis Wizard, refer to *Pro-Motion User's Guide* for detailed information on the Axis Wizard.

Axis 1 Wizard
PMD
PRO MOTION
Welcome to the Axis Wizard
This wizard will guide you through the motor connections and parameters for an axis. A description of each processor parameter can be found in the Programmer's Command Reference.
Select Cancel at anytime to close the wizard and disable motor output.
To continue, click Next
< Back
Next >
Cancel

Upon a normal completion of the Axis Wizard, the axis will be ready to make a controlled move. Depending on the signals connected, this may also mean that limit switches, and other hardware connections are functioning properly.

The most common reasons for the Axis Wizard to not complete normally are an inability to auto-tune the servo motor, or problems determining the correct commutation sequence for Brushless DC motors when commutated by the Magellan Motion Processor. Should this happen, it is possible to perform a manual tuning or commutation setup if desired. Refer to the *Pro-Motion User's Guide* for more information, or call PMD for technical assistance.

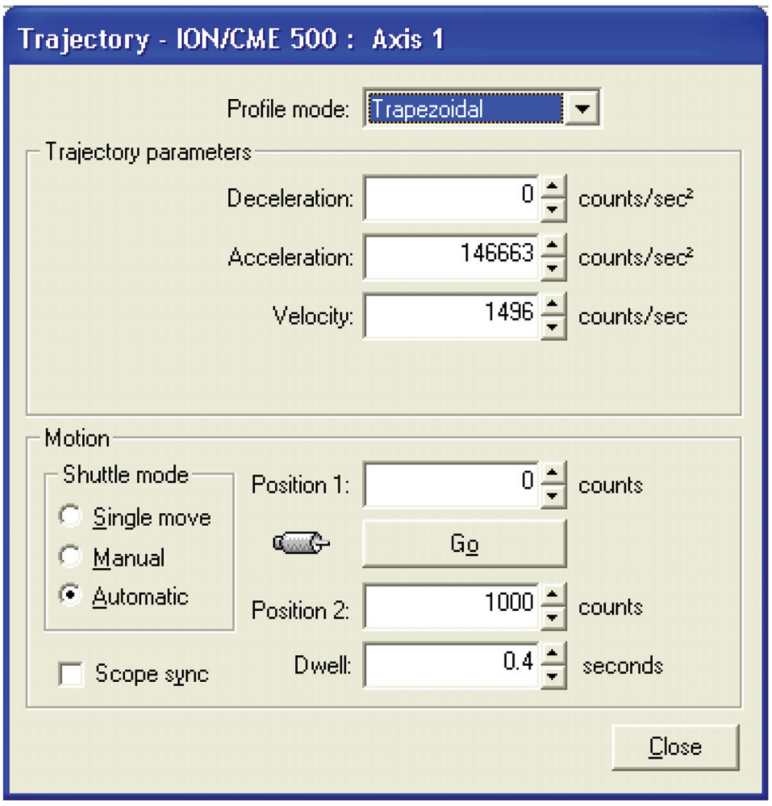
The Axis Wizard auto tuning routine, which is used with servo motors, is designed to provide stable, but not optimal, parameters for motion. Pro-Motion provides a wealth of functions including a high speed hardware trace oscilloscope that can assist you in determining optimal servo parameters. Values provided by the axis wizard during auto tuning may or may not be safe for your system, and it is up to the user to determine if and when they should be used.

2.10.6 Performing a Simple Trajectory Move

The last step in first time system verification is to perform a simple move for each axis.

To perform a simple move:

1. In the Project Window, select the motion axis that you would like to move by clicking the corresponding icon.
2. Click the Axis view button on the far right of the toolbar. Alternatively, click Axis View on the Axis menu. Your screen organization changes to give easy access to windows that are used while exercising the motion axes.
3. Click the Trajectory button in the Axis Control window. The Trajectory dialog box appears.



4 In the Profile mode list, select Trapezoidal.

5 Enter motion profiles for deceleration, acceleration, velocity, and destination position (Position 1) that are safe for your system and will demonstrate proper motion.

Pro-Motion provides various selectable units for distance and time, but defaults to units of encoder counts (or pulses for step motors) for distance and seconds for time. This means the default units for velocity are counts/sec, and the default units for acceleration and deceleration are counts/sec^2. So for a motor that has 2,000 counts per rotation, to perform a symmetric trapezoidal move of 25 rotations with a top speed of 5 rotations per second and with an acceleration time of two seconds, the parameters in the Trajectory dialog box would be set as follows:

Deceleration: 5,000 counts/sec^2

Acceleration: 5,000 counts/sec^2

Velocity: 10,000 counts/sec

Position 1: 0 counts

Position 2: 50,000 counts

6 Click Go and confirm that the motion occurred in a stable and controlled fashion.

Congratulations! First-time system verification for this axis is now complete.

3. Operation

3

In This Chapter

- ION/CME Block Diagram
- Communication Port
- PWM Power Stage
- DC Bus
- Trace Buffer
- Operational and Fault Modes

3.1 ION/CME Block Diagram

ION/CME combines the function of a user code execution platform, motion controller, and amplifier. It directly interfaces to a host computer using an Ethernet or serial interface, and connects to all power and feedback signals required to drive a DC Brush, Brushless DC, or step motor. Refer to Figure 3-1.

In addition to the C-Motion Engine and the Magellan/ION Motion Processor, ION/CME incorporates several major subsystems including a communications system, a high performance MOSFET-based power stage, a DC Bus conditioning system, a trace buffer, and a digital and analog I/O interface.

The following sections describe these major sections of the ION/CME Digital Drive. For a complete description of the Magellan Motion Processor, see the *Magellan Motion Processor User's Guide* and the *Magellan Programmers Command Reference.*

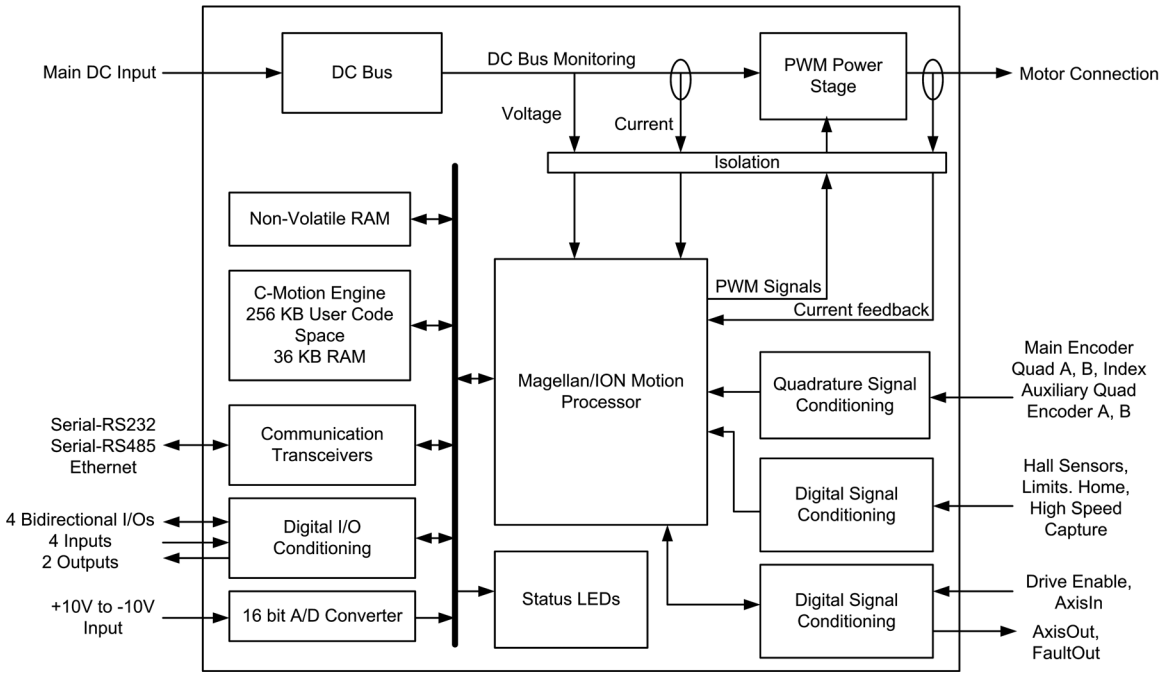


Figure 3-1: ION/CME block diagram

3.2 Communication Port

3.2.1 Ethernet

The ION/CME features a standard 10/100Mbps Ethernet interface. An RJ45 connector with link lights is provided for the connection.

3.2.2 RS232/485

The ION/CME supports both the RS232 and RS485 protocols. A simplified transceiver circuit diagram is shown in Figure 3-2. Pin 8 on the RJ45 connector is used to select between RS232 and RS485 operation. For RS232, pin 8 can be tied high to 3.3V or simply left floating. For RS485 operation, pin 8 must be tied to IO_Gnd.

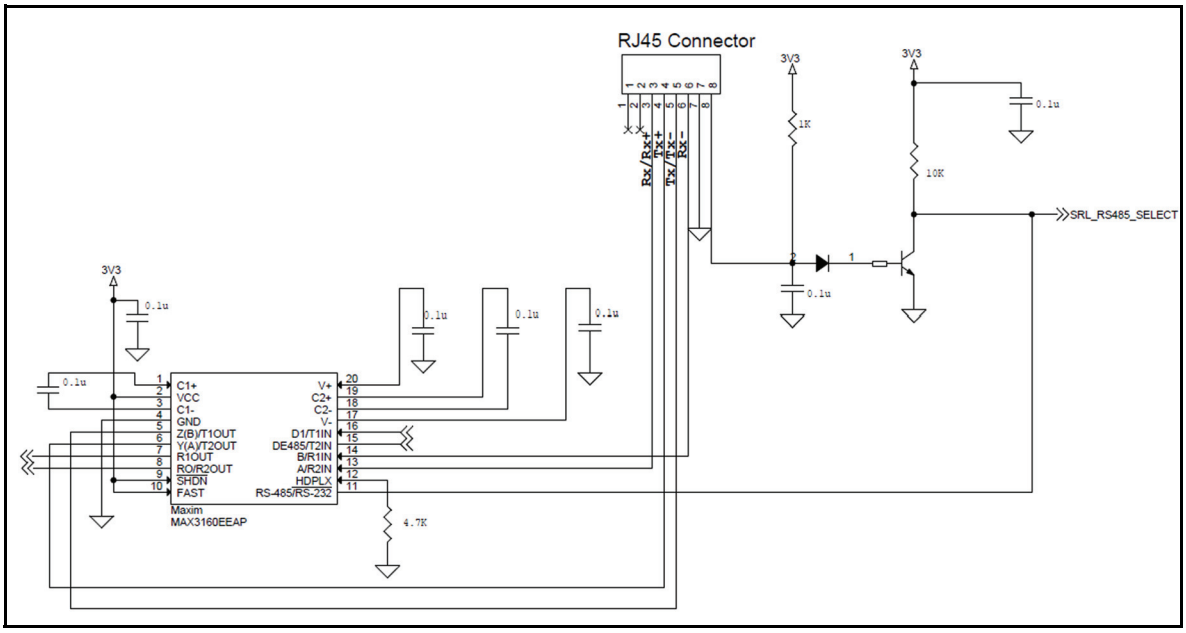


Figure 3-2: Simplified serial transceiver diagram

ION/CME supports point-to-point and multi-drop networking in RS485 and point-to-point only in RS232.

The Select line (pin 8) is read only once when the ION/CME comes out of powerup reset. The communications cable must be connected before power is supplied to the ION/CME module.

3.3 PWM Power Stage

The ION/CME module contains a high-efficiency MOSFET power stage with PWM control and phase current feedback. A slightly different configuration is used for each motor type.

- DC brush motors are driven with an H-Bridge consisting of 4 MOSFETs
- Brushless DC motors are driven with a 3-phase bridge consisting of 6 MOSFETs
- Step motors are driven with two H-Bridges, one for each phase, for a total of 8 MOSFETs

The use of 3-phase and H-Bridge topologies provides full 4-quadrant operation from a single non-isolated DC supply.

ION/CME uses an advanced PWM switching scheme that minimizes the ripple current on the motor windings while maximizing the current loop performance. The PWM frequency is selectable between 20 kHz and 40 kHz to cover a broad range of motor inductance. The fundamental frequency of the ripple current is at twice the PWM frequency and well out of the audible range in all cases.

Two channels of phase current feedback are used for brushless DC and step motor current loops. In the brushless DC version, the third phase is simply calculated as the negated sum of the other two phase currents. For DC brush motors, only one phase current feedback is used.

By monitoring the DC bus voltage, the DC bus current, and the output phase currents, the ION/CME Digital Drive's output stage is fully protected from overcurrent, overvoltage, and undervoltage faults and line-to-line, line-to-power supply, and line-to-earth/case ground short circuits. The Magellan Motion Processor also implements I^2t current foldback and automatic holding current reduction for step motors.

3.3.1 I^2t Current Foldback Protection

ION/CME uses the current feedback to implement I^2t current limiting. This feature protects the drive by controlling its ability to operate above continuous current ratings. This protection feature is active in all operating modes.

When the current loop is enabled and the I^2t energy limit is exceeded, ION/CME will automatically fold back the phase currents to a user programmable continuous current limit value. Alternatively, ION/CME can be configured to fault and disable the output stage when the I^2t energy limit is exceeded.

When the current loop is disabled (ION/CME is operating in voltage control mode only) and the I^2t energy limit is exceeded, ION/CME will always fault and disable the output stage.

3.3.2 Overtemperature Protection

ION/CME uses digital temperature sensors to monitor the operating temperature of the output stage power MOSFETs. The motion processor communicates with the sensors over the built-in SPI bus. If an overtemperature condition is detected, ION/CME shuts down the output stage, indicates the fault with the Module Status LED and optionally activates FaultOut.

The overtemperature threshold is user-settable to any value below the maximum-rated operating temperature of the output stage. See Section 7.4, ION/CME Protection Circuits, for the programmable overtemperature range and the *Magellan Motion Processor Programmer's Command Reference* for more information on setting the temperature threshold.

Refer to the *Magellan Motion Processor User's Guide* and the *Magellan Motion Processor Programmer's Command Reference* for more information on Operating Modes and on setting up these current foldback parameters.

3.3.3 Power Stage Scaling Parameters

To correctly control various ION/CME features via the Magellan Motion Processor it is helpful to know certain drive-specific scale factors. The following tables summarize these values.

3.3.3.1 ION/CME Power Stage Scaling Parameters

Parameter	Commands	Scaling	Example
Current	**GetCurrentLoopValue** **GetFOCValue**	1.296 mA/count	A value of 12,345 from the command **GetCurrentLoopValue** for the ActualCurrent parameter corresponds to a current of 12,345 counts * 1.296 mA/count = 15.999A.
Step motor & Brushless DC*: Continuous RMS Current Limit	**SetCurrentFoldback** **GetCurrentFoldback**	.4587 mA_{RMS}/count	To set a continuous current limit of 5.00A_{RMS} using the **SetCurrentFoldback** command a value of 5,000mA_{RMS}/.4587 mA_{RMS}/count = 10,900 should be used.
DC Brush*: Continuous DC Current Limit	**SetCurrentFoldback** **GetCurrentFoldback**	.5619 mA_{DC}/count	To set a continuous current limit of 5.00A_{DC} using the **SetCurrentFoldback** command a value of 5,000mA_{DC}/.5619 mA_{DC}/count = 8,898 should be used.
Step motor & Brushless DC* I^2t Energy	**SetCurrentFoldback** **GetCurrentFoldback**	.0923 A_{RMS}^2Sec/count	To set a foldback total energy value of 100.0 A_{RMS}^2Sec using the **SetCurrentFoldback** command, a value of 100.0 A_{RMS}^2Sec/.0923 A_{RMS}^2Sec/count = 1,083 should be used.
DC Brush* I^2t Energy	**SetCurrentFoldback** **GetCurrentFoldback**	.1385 A_{DC}^2Sec/count	To set a foldback total energy value of 100.0 A_{DC}^2Sec using the **SetCurrentFoldback** command, a value of 100.0 A_{DC}^2Sec/.1385 A_{rms}^2Sec/count = 722 should be used.

*Brushless DC motors used in Hall-based commutation should use the A_{DC} scale factors. All other Brushless DC motor modes should use the A_{RMS} scale factors.

3.3.4 Power Stage Defaults and Limits

To correctly control various ION/CME power stage features via the Magellan Motion Processor, it is helpful to know certain drive-specific defaults and limits. The following tables summarize these values.

3.3.4.1 ION/CME Power Stage Defaults and Limits

Parameter	Default value	Limit
Brushless DC model: Foldback Continuous RMS Current	8.073A_{RMS}	Must be <= 8.073A_{RMS}
Brushless DC model: Foldback Total Energy	443.1 A_{RMS}^2sec	Must be <= 443.1 A_{RMS}^2sec
DC Brush model: Foldback Continuous DC Current	9.889A_{DC}	Must be <= 9.889A_{DC}
DC Brush model: Foldback Total Energy	664.7 A_{DC}^2sec	Must be <= 664.7 A_{DC}^2sec
Step motor model: Foldback Continuous RMS Current	5.052A_{RMS}	Must be <= 5.052A_{RMS}
Step motor model: Foldback maximum energy	443.1 A_{RMS}^2sec	Must be <= 443.1 A_{RMS}^2sec

For the ION/CME, default values and limits for the Foldback Continuous Current Limit and Foldback Energy Limit are designed to be safe for operation in the drive's highest output mounting option, namely, horizontal to cold plate. See Section 2.4, ION/CME Hardware Configuration and Mounting, for information on ION/CME mounting options.

If the ION/CME drive is being operated at a lower voltage, it may be possible to specify values for Foldback Continuous Current Limit and Foldback Energy Limit that are higher than the default, but lower than or equal to the limit, since the continuous output current rating of the ION/CME drive is higher for lower input voltages. See Section 7.1, ION/CME Drive Ratings, for drive output specifications.

For other mounting configurations, or for use with motors that have lower current and energy limits, it may be useful to set these parameters to values lower than the default values.

It is the responsibility of the user to set the Foldback Continuous Current and Foldback Energy Limit parameters to values that are safe for the specific ION/CME mounting configuration and motor setup being used.

3.4 DC Bus

3.4.1 DC Bus Current Monitoring

ION/CME monitors both the positive and negative DC bus current to detect overcurrent conditions including: line-to-line, line-to-power supply, and line-to-case-ground short circuits. Both hard short circuits and excessive current conditions are detected. ION/CME can even detect some "ground fault" conditions caused by a partial winding short circuit between winding and case within a motor.

When an overcurrent condition occurs, the output stage is shut down and the ION/CME module goes into the hard fault state. See Section 3.6.1, Hard Fault State, for a description of this state.

3.4.2 DC Bus Overvoltage and Undervoltage

ION/CME monitors the main DC bus voltage for overvoltage and undervoltage conditions. These thresholds are user-settable within the voltage operating range of the drive.

When the DC bus voltage drops below the undervoltage threshold, ION/CME shuts down the output stage, indicates the fault with the Module Status LED, and optionally activates FaultOut.

There are two ways for the DC bus to exceed the overvoltage threshold:

1. The supplied DC power is too high. There is little the ION/CME module can do about this. ION/CME simply turns off the output stage, indicates the fault with the Module Status LED and optionally activates FaultOut.
2. The motor is decelerating at a rate too high for the DC power supply to absorb the regenerated energy and the DC bus "pumps up." ION/CME will protect itself by turning off the output stage. It also indicates the fault with the Module Status LED and optionally activates FaultOut.

In either case, the DC bus voltage must then fall below the threshold before the module exits this fault state and can be re-enabled.

3.4.3 IO_5V Monitor

ION/CME features a separate 5V supply for powering external encoders, Hall sensors, and other I/O devices. This supply is monitored to detect overloading or out-of-tolerance operation and if either condition occurs, ION/CME goes into the hard fault state. See Section 3.6.1, Hard Fault State, for a description of this state.

3.4.4 Motion Processor 3.3V Supply Monitor and Reset Circuit

The 3.3V supply for the motion processor automatically forces the processor into the reset state if the supply voltage falls out of regulation.

3.4.5 DC Bus Scaling Parameters

To correctly control ION/CME DC Bus features via the Magellan Motion Processor it is helpful to know the DC Bus scale factor. The following table summarizes this value.

3.4.5.1 ION/CME DC Bus Scaling Parameters

Parameter	Commands	Scaling	Example
Bus Voltage	**GetBusVoltage** **SetBusVoltageLimits** **GetBusVoltageLimits**	1.361 mV/count	A value of 12,345 from the command **GetBusVoltage** corresponds to a voltage of 12,345 counts * 1.361 mV/counts = 16.801V

3.4.6 Undervoltage and Overvoltage Limits

3.4.6.1 ION/CME DC Bus Defaults and Limits

Parameter	Default value	Limit
Undervoltage Limit	9.935V	Must be >= 9.935V and <= 56.00V
Overvoltage Limit	60.02V	Must be <= 60.02V and >= 20.00V

3.5 Trace Buffer

Trace capture is a powerful feature of the Magellan Motion Processor that allows various parameters and registers to be continuously captured and stored to an internal memory buffer. The captured data may later be downloaded by the host using software commands.

Data traces are useful for optimizing DC brush and brushless DC performance, verifying trajectory behavior, capturing sensor data, or to assist with any type of monitoring where a precise time-based record of the system's behavior is required.

The ION/CME module features 1.5 kB RAM for trace. This will hold up to 384 trace samples. Refer to the *Magellan Motion Processor User's Guide* and the *Magellan Motion Processor Programmer's Command Reference* for complete information on trace configuration and operation.

3.6 Operational and Fault Modes

The ION/CME is commanded by the host controller to perform various motion control functions. During the course of these operations it is possible for the ION/CME to enter various fault states based on operational conditions within the power stage, the motor, the electrical bus, or based on the state of the Enable input signal.

Hard electrical faults are serious module or system malfunctions that must be rectified before proceeding.

The following tables summarize the operational and fault modes of the ION/CME Digital Drive. More information about these modes can be found in the *Magellan Motion Processor User's Guide*.

Condition	Details	Output Stage	FaultOut	Module Status LED
Enabled	/Enable = low. Normal operation in programmed operating mode	On	Low (inactive)	Green/solid
Disabled	/Enable = high	Off	Programmable	Green/blinking (slow)
Overvoltage	DC bus voltage exceeded programmable threshold	Off	Programmable	Red/blinking (fast)
Undervoltage	DC bus voltage below programmable threshold			
I^2t Current Foldback	Output stage disabled by I^2t foldback protection	Off	Programmable	Red/blinking (slow)
Overtemperature	Power stage temperature exceeded programmable threshold			

Hard Electrical Fault	Details	Output Stage	FaultOut	Module Status LED
Overcurrent	Short circuit or overload	Off	High (active)	Red/solid
Ground Fault	Excessive current to ground			
IO_5V Fault	Overloaded/out-of-tolerance			
Internal Logic Fault	Internal hardware failure			

3.6.1 Hard Fault State

All hard electrical faults put the ION/CME into the hard fault state. In this state communications and CME user code execution are allowed along with a few Magellan commands, but otherwise the unit is dormant. The table below summarizes what operations are allowed when the ION/CME is in hard fault state:

Operation	Status
ION/CME reset command	Not allowed
Magellan **GetVersion** command	Allowed
Magellan **GetDriveFault** command	Allowed
All other Magellan commands	Not allowed
All other PRP commands	Allowed
CME user code execution	Unaffected, except restrictions on Magellan commands as noted above

.

The ION/CME module should be disabled and disconnected from its power source before any attempt is made to fix a hard fault condition.

The following sequence should be used to recover from the hard fault state:

1. Unless the failure is clearly caused by external circumstances, the ION/CME module should be disconnected from the serial network, as well as disconnected from all external hardware such as the motor, motor encoder, power supply, etc.
2. With all external hardware disconnected, restore the module power. If the unit is still in the hard fault state as indicated by the red Module Status LED, the drive is likely to have sustained an unrecoverable failure, and should be considered unusable thereafter. A replacement ION/CME module should be used in the application.
3. If the Module Status LED indicates that a fault is no longer present, the cause can be determined by reconnecting the communications cable, cycling power again, and reading the Drive Fault Status from the ION/CME module. See the *Magellan Motion Processor User's Guide* for more information on reading the Drive Fault Status.
4. Once the nature of the fault is known, it must be corrected. It is always the responsibility of the user to maintain safe operating conditions of the ION/CME module as well as all associated electronics or hardware.
5. With the source of the problem corrected, the ION/CME module can be reinstalled and reconnected. It should now function normally.

4. ION/CME Control

In This Chapter

- Communication Protocols
- ION/CME Access Basics
- Magellan Motion Processor Functions
- General Purpose Digital I/O
- Analog Input
- C-Motion Engine Functions
- Communications Functions
- ION/CME Reset
- Non-volatile Memory
- Setting Module Defaults
- ION/CME Command Summary

4.1 Communication Protocols

ION/CME Digital Drives can be controlled by an external host controller, can be operated internally using application code downloaded into the C-Motion Engine, or can operate both from external and internal control.

The ION/CME Ethernet and serial ports can be used to send standard commands to IONs attached to the network, or can be programmed to implement a custom-designed protocol. This high level of communication flexibility makes the ION/CME an ideal platform for integration into a large variety of control architectures.

The communication protocol that makes all of this possible is called PRP (PMD Resource access Protocol). This manual will introduce some basic aspects of this protocol, but for a complete description of PRP refer to the *PMD Resource Access Protocol Programmer's Reference.*

4.1.1 ION/CME Control Notes

When commanding the ION/CME using PMD's standard command language, most ION/CME users will not concern themselves with the low level details of communication command protocols because they will use the library of C-language routines provided by PMD.

This library of C-language functions insulates the user from protocol and platform details by providing virtualized C-language interfaces to all supported commands. So, for example, code that is written to control a Magellan located on a serial-connected ION/CME will work just as well when used with an Ethernet-connected ION/CME, or microprocessor-connected Magellan IC on a user-designed motion control card.

4.2 ION/CME Access Basics

Access to the ION/CME from the Ethernet or serial port is provided by a protocol called the PMD Resource access Protocol (PRP). This easy-to-use yet powerful system utilizes actions, resources, and addresses to access the ION/CME's functions. Various ION/CME functions are organized into resources, and resources process actions sent to them. Actions can send information, request information, or command specific events to occur. Addresses allow access to a specific resource on the unit, or connected to it, via the Ethernet or serial connections.

A basic communication to the ION/CME consists of a 16-bit PRP header and an optional message body. The message body contains data associated with the specified PRP action, but some actions do not require a message body. After a PRP communication is sent to the ION/CME, a return communication is sent by the ION/CME which consists of a PRP header and an optional return message body. The return message body may contain information associated with the requested PRP action, or it may contain error information if there was a problem processing the requested action.

The ION/CME supports five resource types. The ***Device*** resource indicates functionality that is addressed to the entire card, the ***MotionProcessor*** resource indicates a Magellan Motion Processor, the ***CMotionEngine*** resource indicates the C-Motion Engine, the ***Memory*** resource indicates a type of memory and the ***Peripheral*** resource indicates a communications connection.

There are ten different PRP actions including Command, which is used to send commands to resources such as the Magellan Motion Processor, Send and Receive, which are used to communicate using the Ethernet and serial ports, and Set and Get, which are used to load or read parameters.

The *PMD Resource Access Protocol Programmer's Reference* describes all of these constructs in more detail. In the subsequent sections of this chapter a summary of the PRP actions that are required to access each ION/CME function are included with the descriptions of the functions themselves.

4.3 Magellan Motion Processor Functions

The Magellan Motion Processor block pictured in Figure 4-1 forms the core of ION/CME. Here is an overview of the functions provided, or managed, by the Magellan Motion Processor on the ION/CME.

- Profile generation
- Pulse & direction signal processing
- Quadrature encoder processing and index capture
- DC brush and brushless DC servo loop closure
- Breakpoint processing
- AxisIn and AxisOut signal processing
- Trace
- Motion error detection, tracking windows, and at-settled indicator
- Limit switches

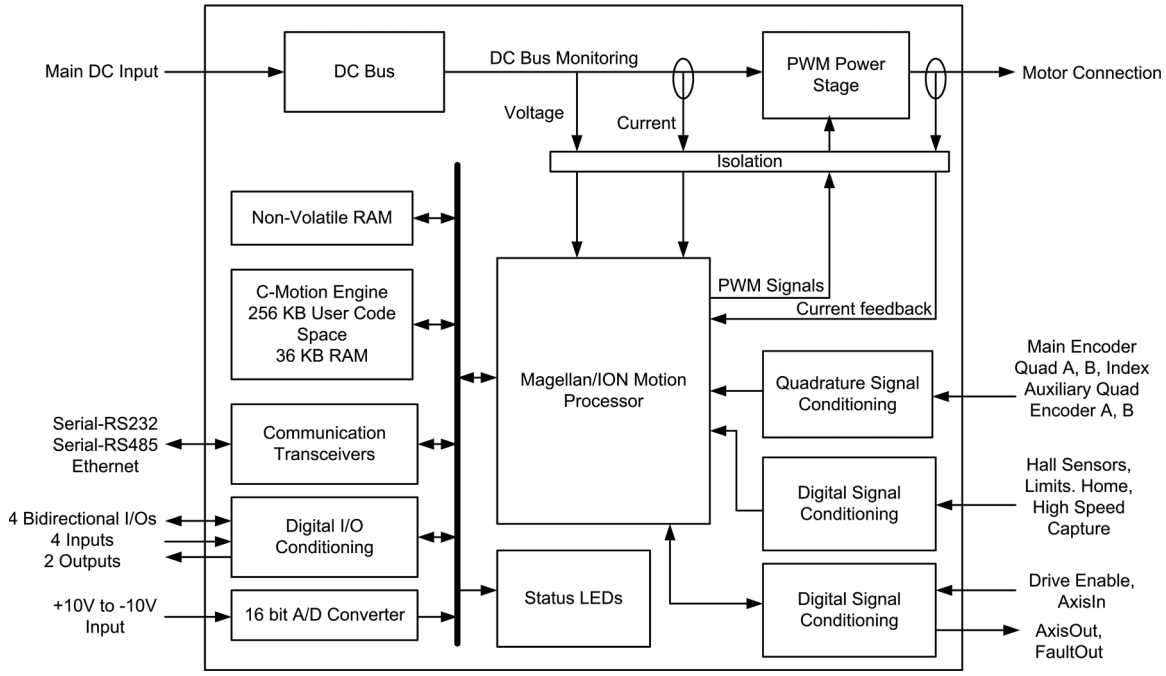


Figure 4-1: ION/CME block diagram

The Magellan Motion Processor interfaces with motion hardware components such as feedback encoders, signal generation hardware, and others through various signal conditioning circuitry.

The Magellan instruction set is very flexible and powerful. The following example, which would be used to set up and execute a simple trapezoidal profile, illustrates just a small part of the overall command set:

```
SetProfileMode Axis1, trapezoidal      // set profile mode to trapezoidal for axis 1
SetPosition Axis1, 12345               // load a destination position for axis 1
SetVelocity Axis1, 223344              // load a velocity for axis 1
SetAcceleration Axis1, 1000            // load an acceleration for axis 1
SetDeceleration Axis1, 2000            // load a deceleration for axis 1
SetUpdateMask Axis1, Profile           // specify that an update of profile parameters only
                                       // is to occur
Update Axis1                           // Double buffered registers are copied into
                                       // the active registers, thereby initiating the move
```

Magellan instructions are encoded in packets, which are sent to and from the Magellan Motion Processor. The Magellan processes these packets, performs requested functions, and returns requested data. Within the ION/CME, the Magellan connects to the ION/CME's communications bus, which allows the Magellan to be controlled via the C-Motion Engine, or via an external host controller connected to the ION/CME by Ethernet or serial port.

Two manuals describe how the Magellan Motion Processor operates and how it is programmed: the *Magellan Motion Processor User's Guide,* and the *Magellan Motion Processor Programmer's Command Reference.* These documents also describe VB-Motion, and C-Motion, which are the software libraries that are used to send commands to the Magellan chip and exercise its many functions.

4.3.1 Accessing the Magellan Motion Processor

To send and receive command packets to the Magellan Motion Processor the PRP action **Command** is used. The Magellan command packet is loaded into the PRP message body, and the return PRP message body contains the return packet provided by the Magellan. A return without error indicates that the command was processed successfully. If an error occurred while the Magellan was processing the command, the message body is loaded with the specific error that occurred. For more information, see the *PMD Resource Access Protocol Programmer's Reference.*

In addition to accessing the on-ION/CME Magellan, it is also possible to access Magellan Motion Processors that are connected via the ION/CME's attached Ethernet networks. An additional PRP action, **Open**, sent to either the ***Device*** or the ***Peripheral*** resource, is used to establish a connection to such a motion processor. See the *PMD Resource Access Protocol Programmer's Reference* for more information on connecting to motion processors on attached networks.

4.3.1.1 Magellan Reset

Although a reset occurs automatically during power-up, it is sometimes desirable to reset the Magellan Motion Processor explicitly through a user-initiated action. The PRP action **Reset**, when sent to the ***MotionProcessor*** resource, causes a reset of the Magellan Motion Processor. This reset affects the Magellan Motion Processor, and a number of Magellan-controlled signals. Note however that this type of reset is different than a full ION/CME reset initiated via the PRP action **Reset**, described in Section 2.8, Applying Power,.

After a Magellan reset occurs, some of the ION/CME's output signals will be driven to known states. These are summarized in the following table:

Signal Name	State
AxisOut	1
FaultOut	0

4.4 General Purpose Digital I/O

In addition to special-purpose digital signals, such as ***AxisIn, AxisOut, Home,*** and ***QuadA*** which are input to or output from the ION/CME, and which are directly processed by the Magellan Motion Processor, the ION/CME also supports several general-purpose input and output signals through its Indexer connector. There are two outputs, four inputs, four bi-directional I/Os and one 16-bit ±10V analog input. These signals provide a convenient way of accessing additional application-specific general purpose digital I/O.

The I/Os are accessed via the CME peripheral functions: ***Open Peripheral Parallel***, ***Peripheral Read*** and ***Peripheral Write***.

The general purpose digital inputs are TTL-compatible with a typical input range of 0-5.5V. The inputs are overvoltage protected to 30V.

The general purpose digital outputs are 5V TTL-compatible with an output sink current of 100mA. There is an internal pull-up to 5V on Digital Outputs 1 & 2. The bidirectional I/O lines have an internal pull-up to 5V.

4.4.1 Digital Inputs

The eight digital inputs are read via the ***Peripheral Read*** function and are contained in the lower 8 bits of the returned 16-bit word.

Signal Name	Pin No.	Bit No.
DigitalIn1	9	0
DigitalIn2	10	1
DigitalIn3	11	2
DigitalIn4	12	3
DigitalIO5	13	4
DigitalIO6	14	5
DigitalIO7	15	6
DigitalIO8	16	7

The following code sequence illustrates how to read the state of the eight digital inputs:

```
// open a peripheral handle to the digital input signals
PMDPeriphOpenPAR(&hPeriph, &hDevice, PMD_ADDRESS_ION_DI, 0, PMDDataSize_16Bit);
// read the current state of the digital inputs.
PMDPeriphRead(&hPeriph, &data16, 0, 1);
```

4.4.2 Digital Outputs

The six digital outputs (four are shared with the digital inputs) are controlled via the ***Peripheral Write*** function. The desired output values are contained in the low 8 bits of the 16-bit word parameter and the bit mask is contained in the high 8 bits of the 16-bit word parameter. The bit mask sets which bits will be affected by the write. The current output state can also be read via the ***Peripheral Read*** function and are contained in the lower 8 bits of the returned 16-bit word.

Signal Name	Pin No.	Bit No.
DigitalOut1	7	0
DigitalOut2	8	1
DigitalIO5	13	4
DigitalIO6	14	5
DigitalIO7	15	6
DigitalIO8	16	7

The following code sequence illustrates how to set the state of the six digital outputs on the Indexer IO Connector:

```
// open a peripheral handle to the digital output signals.
PMDPeriphOpenPAR(&hPeriph, &hDevice, PMD_ADDRESS_ION_DO, 0, PMDDataSize_16Bit);
// read the current state of the digital outputs (optional)
PMDPeriphRead(&hPeriph, &data16, 0, 1);
// set Digital Output 1 to low and bits Digital Input/Output 5 to high.
// a value of 0x1110 will set bits 0 and 3 (DO1 and DIO5) to 0 and 1 respectively. data16= 0x1110:
PMDPeriphWrite(&hPeriph, &data16, 0, 1);
```

4.4.2.1 Bi-directional Signal Considerations

The four bi-directional digital signals are accessed via separate peripheral addresses: One for reading the digital inputs and one for reading and writing the digital outputs.

The digital outputs are open-collector logic. When an output pin is set to 1 (high), the output transistor is off and the pin can be used as an input. When an output pin is set to 0 (low), the output transistor is on which pulls the signal to ground and the pin cannot be used as an input.

4.5 Analog Input

The analog input is a 16-bit ±10V analog input. The input value is read via the ***Peripheral Read*** function. The range of the returned value is 0-65,535 where 0=-10V and 65,535=+10V.

To read the state of the analog input the following code sequence can be used:

```
// open a peripheral handle to the analog input signal.
PMDPeriphOpenPAR(&hPeriph, &hDevice, PMD_ADDRESS_ION_AI, 0, PMDDataSize_16Bit);
// read the current state of the analog input.
// the range of the returned value is 0-65535. (0=-10V 65535=+10V)
PMDPeriphRead(&hPeriph, &data16, 0, 1);
```

The analog input has a voltage range of ±10V. The ION/CME receives both single-ended and differential analog inputs as shown in the following table and Figure 4-2. When used in single ended configuration, ***AnalogIn-*** should be connected to Ground of the transmitter. When used in differential configuration, ***AnalogIn+*** and ***AnalogIn-*** are connected to the differential output of the transmitter. In addition, it is recommended to connect the ground of the transmitter to ***IO_Gnd*** of the ION/CME. Please refer to the diagrams in Figure 4-2.

Analog Input Characteristics	Value/Range
Input Signal Voltage Range	-10V to +10V
Resolution	16 Bits
Maximum Recommended Input Signal Frequency	2 KHz
Throughput	40 Kilo samples per second
Integral Non Linearity Error, Typical	±1 LSB
Integral Non Linearity Error, Maximum	±3 LSB
Overvoltage Protection	-35V to +40V
Common-Mode Range	-10V to +25V
Typical Differential Impedance	108 Kohms
Common Mode Rejection Ratio, Minimum	80 dB

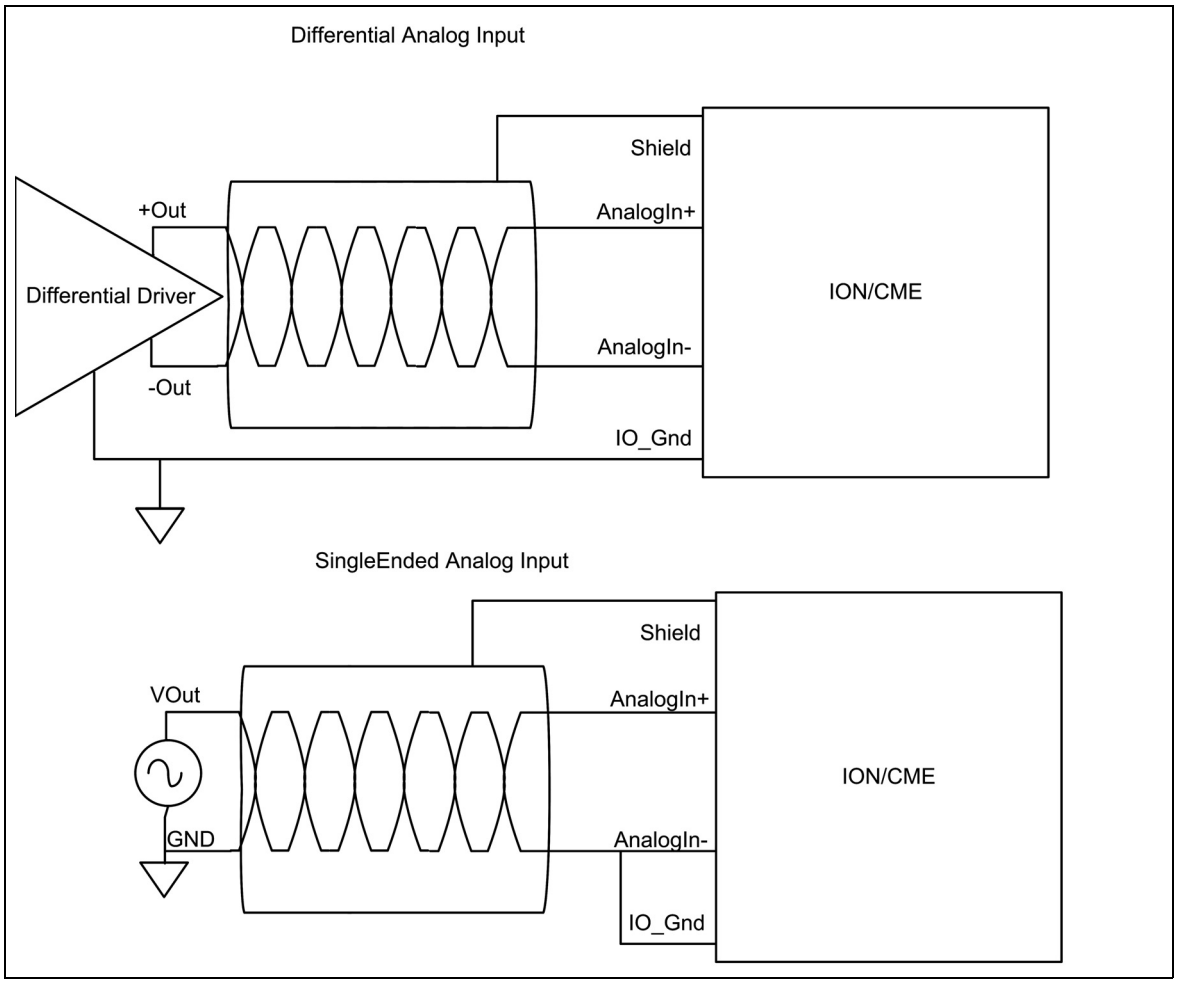


Figure 4-2: Analog inputs simplified diagrams

4.6 C-Motion Engine Functions

The C-Motion Engine on the ION/CME allows C-Motion code to be downloaded and executed on the ION/CME. The C-Motion Engine is a powerful and flexible engine that can be used to:

- Operate ION/CMEs in a standalone mode
- Offload time-critical code from the host to the ION/CME
- Create a complete machine controller that communicates via Ethernet or serial to a cell controller or other high level controller
- Extend the functionality of the Magellan Motion Processor with higher level functions such as contouring, macros, or other complex behaviors
- Lower system cost by combining a supervisor function with a dedicated motion controller function in a single-module format

4.6.1 C-Motion Engine Hardware Configuration

The C-Motion Engine is a self-contained module that provides non-volatile RAM space to store downloaded user application code, RAM space for 'scratch' data variable storage, and connections to the communication bus allowing the C-Motion Engine to send and receive messages through the network ports, communicate with the Magellan Motion Processor, and access other ION/CME resources such as the general purpose I/O.

Creating, compiling, downloading, and verifying a specific user C-Motion application on an ION/CME is accomplished with the C-Motion Engine development system, described in C-Motion Engine Development Tools. The outcome of such a development sequence is a downloadable code image, run on the C-Motion Engine, that contains the user application code and that is executed by the C-Motion Engine on the ION/CME. Figure 4-3 provides an overview of the architecture of the C-Motion Engine

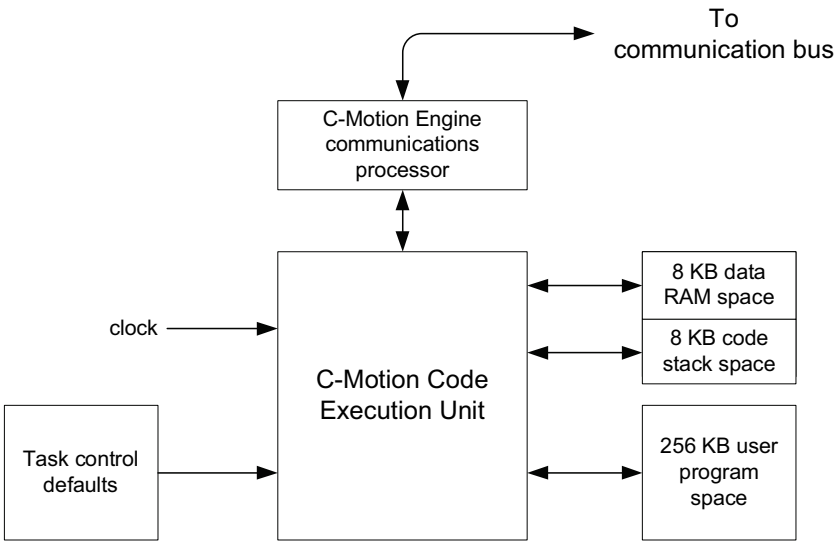


Figure 4-3: C-Motion Engine architecture

The following table provides an operational overview of the memory segments provided by the C-Motion Engine:

Segment	Specification
User program space (stored in flash)	256 KB
User data RAM space	8 KB
User code stack space	8 KB

4.6.2 Powerup & Operation

Upon reset or power up the C-Motion Engine initializes itself and checks to see whether execution of user application code, if downloaded, should automatically begin. If the factory default settings have not been changed, the C-Motion Engine will hold in a wait state, and code execution will not occur.

While there are numerous safety checks and features built into the C-Motion Engine system, application code developed for the C-Motion Engine is C-based, and thus there are limits to code size, RAM usage, and stack usage that should be observed during run time operation of downloaded C-Motion code. The table in the previous section provides these numerical limits.

For user downloaded code that does not correctly observe these limits, or for files that have become corrupted, there are a number of fault conditions that can occur while the C-Motion Engine is executing downloaded user application code. These very serious run-time faults include instruction errors - indicating that an unknown instruction was encountered during execution of the user's code, and address faults - indicating that either a program space or RAM space access limit was violated. If either of these conditions occurs, the C-Motion Engine will immediately halt user code execution, and reset the ION/CME. This C-Motion Engine-initiated reset is identical to the reset that occurs after sending a PRP **Reset** action, except that the cause of the reset is recorded as 'C-Motion Engine user code Fault' rather than 'commanded' reset. See Section 2.8, Applying Power, for more information on the **Reset** command and on retrieving the reset cause.

Whether or not user application code is running, after reset or power up, the C-Motion Engine begins processing PRP actions sent to it. These commands are typically sent from a host controller. The supported commands include functions such as checking the downloaded user application code version stored in the C-Motion Engine, and sending and receiving messages to the user code loaded onto the C-Motion Engine.

For additional guidelines on managing run-time usage of the C-Motion Engine see the *C-Motion Engine Development Tools Manual.*

4.6.3 Task Control

The primary purpose of the C-Motion Engine is to execute user application code that has been downloaded to it using the C-Motion Engine development system.

In a production environment, this code will typically automatically start upon power up, and run continuously while the system is in operation. For debugging however, there are a number of additional controls.

At any point in time it is possible to stop or restart execution of the C-Motion Engine user application code. To access this function the PRP action **Command** is sent to the ***CMotionEngine*** resource.

> Extreme caution should be exercised when stopping or starting user application code running on the C-Motion Engine, as this may cause unexpected or unsafe motion. It is the responsibility of the user to determine whether stopping or restarting of user application code is safe and appropriate.

Whether or not the user application code automatically executes upon powerup or reset can also be controlled. The two options are operation under manual mode, in which case the user's code will not begin execution until an explicit start command is given, and auto-start, where the code automatically begins execution from power up or reset. The PRP action **Set** sent to the ***CMotionEngine*** resource allows setting of the user code start mode.

In addition to these functions, it is also possible to determine whether the user application code is presently running or not. This status information may be useful during code debugging, or to help diagnose problems. This capability is accessed via a **Get** action sent to the ***CMotionEngine*** resource.

For a detailed description of the supported ION/CME commands, see the *PMD Remote Access Protocol Programmer's Reference.*

4.6.4 Sending Messages To/From User Application Code

A common function of user application code running on the C-Motion Engine is to parse command messages sent to it by a host controller. For example, a user might write code for the C-Motion Engine that responds to an "Extend Robot Arm" command sent by the host controller, and then send a series of commands to the Magellan Motion Processor to execute this motion sequence. At the end of the motion sequence the user application code might send an "Arm Extended" message confirming the movement sequence has completed.

One method of achieving this is to use the ION/CME's peripheral mechanism to open, and operate, a low-level communications link via the Ethernet or serial link. This method has the advantage of giving relatively direct control over the communication traffic. The disadvantage is that the user has to implement specific send and receive communications in the host controller, and the C-Motion Engine needs to have similar code implemented that can process these messages.

Another method that may be more convenient, particularly during early debugging of the user's application code, is to use the capability of the PRP system to connect directly to the user application code on the C-Motion Engine. Messages sent and received by the C-Motion Engine from a host controller are stored in a special buffer, and can be easily read or written to by the user application code. In addition, PMD's Pro-Motion application supports a simple way of entering, sending, and/or receiving such messages. This makes it easy to manually enter commands from Pro-Motion and exercise the user application code which is programmed to parse these messages.

To utilize this approach, a PRP **Send** or **Receive** action is sent to the ***CMotionEngine*** resource. To receive these messages within the C-Motion Engine a special 'user packet' peripheral is opened. For more information see the *PMD Resource Access Protocol Programmer's Reference.*

In addition to these communications commands, when sent to the ***CMotionEngine*** resource, the PRP action **NOP** performs a basic connection check. The message body is empty. A return without a PRP error code indicates that the C-Motion Engine is accessible and processing commands.

4.6.5 Connecting To the C-Motion Engine Code During Development

To develop code that is downloaded to the C-Motion Engine, a communications link is required between the C-Motion Engine and the PC-based C-Motion Engine Development Environment. This link contains the information required for code downloads, as well as other information utilized during application debugging.

While Ethernet or serial can both be used as the communications link, typically this link is chosen to be Ethernet because it is significantly faster than the other two. If the 'production machine' network is also Ethernet, then only one network need be used for both code development, and operation of the machine.

It is also possible to use separate communication channels, so that one type of link is used for code development and download, and another for the 'application' communications. This has the advantage that application and code development traffic are not intermingled. For example, in a production machine control application that involves a PC and two ION/CMEs communicating via serial, Ethernet can be used as the development link, while the application software contained in the C-Motion code will send and receive messages using the serial port.

Selecting which ION/CME channel will be used for download is specified via the C-Motion development system. For more information see the *C-Motion Engine Development Tools Manual.*

4.6.6 Debug Console Window

During development, the user can use procedure calls similar to printf() from the downloaded application on the C-Motion Engine to send messages to the PC Development Environment for display in a special console window. These console messages may be useful for checking code progress, displaying internal variables, or for other code development-related purposes.

The default console channel is set to 'none', and should be set to a specific Ethernet TCP port to be used during debug. The easiest way to do this is with Pro-Motion using the appropriate setup screens. Alternatively, the PRP action Set with the ***CMotionEngine*** resource and Console sub-action can be used to set the console channel.

4.6.7 Downloading and Verifying User Application Code

The C-Motion Engine development system is used to create, compile, and download user application code. The development system can download the file image for the current code project being worked on, or a specific named file can be downloaded. Downloaded files images end with a ".bin" extension. Only one code image file may be downloaded into the C-Motion Engine at a time. Downloading a new image automatically erases the previous code image.

There are times when it may be useful to read specific characteristics of a code file that has been downloaded into the C-Motion Engine. For example, a host controller in a production environment may want to confirm that the host application code version actually loaded on the C-Motion Engine matches the expected production code version. To accomplish this, the PRP action Get is used, specifying a resource ID of ***CMotionEngine***. Using this command the file name of the downloaded user application code, the checksum of the downloaded file, the date & time of file creation, and the version number of the C-Motion Engine itself (loaded by PMD during production) can be retrieved.

For complete information on the format and function of these, and other PRP actions, refer to the *PMD Remote Access Protocol Programmer's Reference.*

4.7 Communications Functions

The ION/CME provides two different network connection types, Ethernet and Serial. Access to these communication resources is provided via a peripheral connection. A peripheral is a resource, and is utilized by various PRP actions to send and receive messages to network connections.

Basic access to either the Ethernet or Serial port is accomplished by opening a peripheral with the detailed connection parameters that will be used during communications associated with that peripheral connection, and then sending and receiving messages via that peripheral resource address.

For example, to create an Ethernet TCP peripheral connection, the IP Address and port number is provided. If the connection is successfully established, that peripheral is used as the reference for any future communications through that connection.

In the subsequent sections the operational characteristics of the Serial and Ethernet network ports will be detailed.

4.7.1 Ethernet Communications

The ION/CMEs support two different Ethernet protocols, TCP (Transmission Control Protocol) and UDP (User Datagram Protocol). TCP is typically used for primary Ethernet communications to the ION/CME, while UDP is typically used for non-critical applications such as data logging, or for the Pro-Motion console window. See Section 4.6.6, Debug Console Window, for more information on the C-Motion Engine console window.

When used to receive PRP messages, the physical node on the Ethernet network controller is assigned a 32-bit IP (Internet Protocol) address, along with a 32-bit net mask and a 32-bit gateway value. The Netmask is used to indicate which IP addresses are local, and the gateway value is used to route non-local addresses. To correctly receive communications from the host controller, a 16-bit identifier known as a port must also be specified. Note that when used as the connection between the host controller and the ION/CME, TCP rather than UDP communications are used. To determine what the unused IP addresses are for your Ethernet network, and what values for net mask and gateway to use, contact your network administrator.

The PRP messaging system utilizes a default TCP port address of 40100, so this address should not be used for user-created application communications.

By convention, the 32-bit values for IP Address, Net mask, and Gateway are shown in Dotted Quad Notation. In this notation each of the four numbers are separated by dots, and denote a decimal value for each byte of the four byte word

The table below shows the range and default settings for the Ethernet controller of the ION/CME:

Parameter	Range	Default
IP address	0.0.0.0 – 255.255.255.255	192.168.2.2
Net mask	0.0.0.0 – 255.255.255.255	255.255.255.0
Gateway	0.0.0.0 – 255.255.255.255	0.0.0.0
PRP Listen TCP Port	0 - 65,535	40100

Each physical hardware device on an Ethernet network is assigned one IP address; however, a given IP address can have multiple ports. This is useful because it allows user application code running on the C-Motion Engine to open up peripheral connections using port numbers other than the PRP communications port (which has a default value of 40100), thereby allowing PRP messages and application-specific data in any format to co-exist on the same Ethernet IP node.

To create an Ethernet/TCP or Ethernet/UDP peripheral conversation, the IP Address and port are specified in the PRP message body of an **Open** command sent to the ***Device*** resource. To transfer messages via this peripheral connection the PRP actions **Send** and **Receive** sent to the ***Peripheral*** resource are used.

After a reset or at power-up, the ION/CME retrieves default information for the ION/CME Stand-Alone Ethernet port. To change these default values, the PRP **Set** command is sent to the ***Device*** resource.

For detailed information on PRP action formats and function, refer to the *PMD Remote Access Protocol Programmer's Reference.*

4.7.2 Serial Communications

ION/CME provides asynchronous serial communications in either RS232 or RS485 mode. Access to the serial port controller is managed using peripheral connections.

In RS485 mode, the serial port may be operated in either half duplex or full duplex mode. Pin #8 of the Serial Connector selects whether RS232 or RS485 communications mode is used. If left open (the default condition), the ION/CME operates the serial port in RS232 mode. If closed (tied to ground) the serial port is operated in RS485 mode. Note that a change in the status of this pin takes effect only after a power-on or a reset of the ION/CME.

The serial port can be operated at various communication settings as shown in the following table.

Parameter	Range	Serial
Baud rate	1,200 to 460,800	57,600
Parity	none, even, odd	none
# Data bits	5, 6, 7, 8	8
# stop bits	1, 2	1

To create a serial port peripheral connection, the above parameters are specified in the PRP action **Open** with the resource set to ***Device***. Messages to and from the Serial port are transmitted via the **Send** and **Receive** actions sent to the ***Peripheral*** resource. Whenever a new serial port peripheral is opened its previous function is canceled. By default Serial is the console port.

After a reset or at power-up, the ION/CME retrieves default information for the serial port. To change these default values, the PRP action **Set** is sent with a resource of ***Device***.

For detailed information on PRP action formats and function, refer to the *PMD Remote Access Protocol Programmer's Reference*.

4.8 ION/CME Reset

During power-on, or if initiated by a software command, the ION/CME undergoes a reset sequence. When this occurs the Magellan Motion Processor and the C-Motion Engine modules are reset, and some of the ION/CME module's output signals are driven to known states.

To learn more about a Magellan reset, see the *Magellan Motion Processor User's Guide*.

The table below indicates the signals of the ION/CME that are driven to known states during a reset:

Signal Name	State
AxisOut	High
FaultOut	Low (inactive)
DigitalOut1-2	High
DigitalIO5-8	Set to inputs

In addition, upon a reset all module default parameters are reloaded. See Section 4.10, Setting Module Defaults for more information on default values.

4.8.1 Software Commanded ION/CME Reset

A reset occurs automatically during power-up, however it is sometimes desirable to reset the ION/CME explicitly through a user-initiated software command. This can be done via the PRP action **Reset** sent to the ***Device*** resource. Note that this command can only be performed when the ION/CME is not in a hard fault condition.

An ION/CME software reset cannot be performed if the module is in a hard fault state. If attempted, a return error of PMD_ERR_MP_HardFault will occur, and an ION/CME reset will not occur. To reset the ION/CME in this condition you must power cycle the ION unit.

4.9 Non-volatile Memory

The ION/CME module has a general purpose 4,094 byte memory that retains its contents after a module power down or reset. This memory is useful for storing parameters that are set only occasionally and stay with the module, such as machine calibration information.

NVRAM addresses are specified from 0 to 4,093. When writing to this memory, a typical write takes μ30 Secs, however under certain circumstances it can take much longer, up to several 100 mSec. Read speed takes just a few nanoseconds. Byte-size memory operations are not supported by the non-volatile memory. The smallest memory unit that can be accessed is 16 bits.

The non-volatile memory can be rewritten a limited number of times. The worst case write limit cycle is 100,000 times for a given memory address, but in typical operation, the limit is much higher. As a general guideline, to avoid erase/write cycle limit problems, the non-volatile RAM should not be used for general purpose scratch RAM, and should only be used to store permanent or semi-permanent parameters.

To read or write to the NVRAM, a resource address must first be obtained by sending the **Open** action to the ***Memory*** resource. This resource address is used for all further access to the NVRAM. To write data to the NVRAM, the action **Write** is sent to the ***Memory*** resource. To read the contents of the NVRAM, the action **Read** is used.

For complete information on the format and function of these, and other PRP actions, refer to the *PMD Resource Access Protocol Programmer's Reference.*

The typical write time to the non-volatile RAM is 30 μSec, however it may take as long as several 100 mSec. If other portions of the user application code, or any other PRP-connected device, depends on these values having been written, it is recommended that you ensure that the write operation has been completed by adding code that explicitly checks the value, or by waiting a fixed period of time after the NVRAM write operation.

4.10 Setting Module Defaults

The ION/CME utilizes an onboard NVRAM (non-volatile RAM) to hold a number of user-settable parameters that are saved while power is off. The following table shows these parameters as well as their factory default values:

Parameter	Factory default value
Ethernet Communications	
IP Address	192.168.2.2
Net Mask	255.255.255.0
Gateway	0.0.0.0
PRP Port	40100
Serial Communications	
Serial 1 settings	57600, no parity, 8 data bits, 1 stop bit
RS485 duplex	Full
RS485 Address	0
Task Control & User Application Code	
Auto start user code	No
Console output channel	None

These default values become the active parameter settings after a powerup sequence, or after a software commanded ION/CME reset.

To change the default values the PRP action **Set** sent to the ***Device*** resource is used. To read back the current default parameters stored in the module the action **Get** is used. For detailed information on the format of these PRP messages consult the *PMD Resource Access Protocol Programmer's Reference.*

4.11 ION/CME Command Summary

The following table summarizes all PRP commands provided by the ION/CME.

Action	Resource	Sub-action	C Procedure
NOP	Device		**PMDDeviceNoOperation**
	MotionProcessor		**PMDNoOperation**
Reset	Device	Reset	**PMDDeviceReset**
	MotionProcessor	Reset	**PMDReset**
Command	CMotionEngine	Flash	**PMDDeviceStoreUserCode**
		Task	**PMDCMETaskStart**
			PMDCMETaskStop
	MotionProcessor		Various
Open	Device	Memory32	**PMDMemoryOpen32**
		CMotionEngine	**PMDPeriphOpenCME**
		COM	**PMDPeriphOpenCOM**
		TCP	**PMDPeriphOpenTCP**
		UDP	**PMDPeriphOpenUDP**
		Parallel	**PMDPeriphOpenPAR**
	Peripheral	Device	**PMDRPDeviceOpen**
		MotionProcessor	**PMDMPDeviceOpen**
		MultiDrop	**PMDPeriphOpenMultiDrop**
Close	Peripheral		**PMDPeriphClose**
	Device		**PMDDeviceClose**
	MotionProcessor		**PMDDeviceClose**
	Memory		**PMDMemoryClose**
Send	CMotionEngine		**PMDPeriphSend**
	Peripheral		**PMDPeriphSend**
Receive	CMotionEngine		**PMDPeriphReceive**
	Peripheral		**PMDPeriphReceive**
Write	Memory	Dword	**PMDMemoryWrite**
		Word	**PMDMemoryWrite**
	Peripheral	Byte	**PMDPeriphWrite**
		Word	**PMDPeriphWrite**
Read	Memory	Dword	**PMDMemoryRead**
		Word	**PMDMemoryRead**
	Peripheral	Byte	**PMDPeriphRead**
		Word	**PMDPeriphRead**
Set	CMotionEngine	Console	**PMDCMESetConsole**
	Device	Default	**PMDDeviceSetDefault**
Get	CMotionEngine	Console	**PMDCMEGetConsole**
		TaskState	**PMDCMEGetTaskState**
	Device	Default	**PMDDeviceGetDefault**
		ResetCause	**PMDDeviceGetResetCause**
		Version	**PMDDeviceGetVersion**

For additional information on how PRP packets are formatted, and how they are carried over Ethernet as well as other details of PRP processing refer to the *PMD Resource Access Protocol Programmer's Reference.*

5. Options and Accessories

In This Chapter

- Stub Cable Set
- Development Kit Cable and Plug Specifications
- Optional Heat Sink
- Optional DIN Rail Adapter

5.1 Stub Cable Set

The following tables summarize the cables and other accessories that come with each ION/CME Developer's Kit. See the next section for detailed information on each cable type.

Cable (PMD Part #)	Description
Cable-RS232-03-R	9-pin RS232 Communications Cable
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable
Cable-1004-02-R	I/O Stub Cable
Cable-1005-02-R	ION 500 DC Bus Stub Cable
Cable-1006-02-R	ION 500 Motor Stub Cable
Cable-1010-01-R	Indexer Stub Cable
Cable-RJ45-02-R	Male RJ45 cable wired in a straight-through configuration
Adapter-1010-01	RJ45 to DB9 Adapter for RS232

5.2 Development Kit Cable and Plug Specifications

PMD Part #: Cable-RS23203-R	Pin	Signal	Pairing	Color
Description: RS232 Comm cable	1	Select	None	Black*
Length: 2m	2	Tx	P2	White
Cable: 4P, 24AWG, foil shield, Alpha 5474C, or equiv.	3	Rx	P1	Red
	4	No connect		
Notes: Shield connected to shells at both ends.	5	Gnd	P1	Black
*Grounded jumper wire included inside DB9M backshell to use for Select.	6	Rx+	P3	Green
	7	Rx-	P3	Black
	8	Tx+	P4	Blue
	9	Tx-	P4	Black

PMD Part #: Cable-1002-02-R	Pin	Signal	Pairing	Color
Description: Feedback stub cable	1	Drain		
Length: 2m	2	IO_Gnd	P1	Black
Cable: 6P, 22AWG, foil shield, Alpha 2216C or equiv.	3	IO_5V	P1	Red
	4	Hall A	P5	Brown
	5	Hall B	P5	Black
	6	Hall C	P6	Yellow
	7	A+	P2	White
	8	A-	P2	Black
	9	B+	P3	Green
	10	B-	P3	Black
	11	Z+	P4	Blue
	12	Z-	P4	Black

PMD Part #: Cable-1003-02-R	Pin	Signal	Pairing	Color
Description: Auxiliary stub cable	1	Drain		
Length: 2m	2	IO_Gnd	P1	Black
Cable: 3P, 22AWG, foil shield, Alpha 2213C or equiv.	3	IO_5V	P1	Red
	4	No connect		
	5	A+	P2	White
	6	A-	P2	Black
	7	B+	P3	Green
	8	B-	P3	Black

PMD Part #: Cable-1004-02-R
Description: I/O stub cable
Length: 2m
Cable: 13C, 22AWG, foil shield, Alpha 1299C/15 or equiv.

Pin	Signal	Color
1	Drain	
2	IO_Gnd	Black
3	IO_5V	Red
4	IO_Gnd	Blue
5	IO_5V	Red/Yel
6	IO_Gnd	Brown
7	FaultOut	Pink
8	+Limit	White
9	-Limit	Green
10	Home	Orange
11	HSI	Yellow
12	AxisIn	Violet
13	AxisOut	Gray
14	/Enable	Tan

PMD Part #: Cable-1005-02-R
Description: ION 500 DC bus stub cable
Length: 2m
Cable: 3C,16AWG, foil shield, Alpha 5363C or equiv.

Pin	Signal	Color
1	HV	Red
2	AuxV	White
3	PGnd	Black

Note: Drain and PGnd spliced together at Pin 3.

PMD Part #: Cable-1006-02-R
Description: ION 500 Motor stub cable
Length: 2m
Cable: 6C,16AWG, foil shield, Alpha 5366C or equiv.

Pin	Signal	Color
1	A+ (U, M+)	White
2	A- (V)	Green
3	B+ (W, M-)	Orange
4	B-	Blue
5	PGnd	Black

Note: Drain and PGnd spliced together at Pin 5.

PMD Part Number: CABLE-1010-01
Description: Indexer stub cable
Length: 1m
Cable: Multiconductor shielded, ALPHA 6308 or equivalent

Cable-1010-01 is split into 2 shielded cable sections. One section carries twisted pair conductors connected to the analog input. The other section carries conductors connected to the Digital Inputs & Outputs. This ensures that the analog signal is separate and shielded from the rest of the signals on the Indexer Connector.

Pin	Signal	Color
1	Case Shield	Bare
2	IO_Gnd	Black
3	IO_5V	Red
4	AnalogIn-	Black
5	AnalogIn+	Red
6	IO_Gnd	White
7	DigitalOut1	Blue/Red
8	DigitalOut2	Orange/Red
9	DigitalIn1	Green/Black
10	DigitalIn2	Orange/Black
11	DigitalIn3	Blue/Black
12	DigitalIn4	Red/Black
13	DigitalIO5	Black/White
14	DigitalIO6	Red/White
15	DigitalIO7	Green/White
16	DigitalIO8	Blue/White

PMD Part #: Cable-RJ45-02-R
Description: Male RJ45 to male RJ45 cable wired in a straight- through configuration

Length: 2m

Cable:4P, 24AWG,UTP, Cat 5E

Pin	Signal	Color
1	Ethernet Tx+	-
2	Ethernet Tx-	-
3	Ethernet Rx+	-
4	No Connect	-
5	No Connect	-
6	Ethernet Rx-	-
7	No Connect	-
8	No Connect	-

PMD Part #: Adapter-1010-01

Description: ION DB9 to RJ45 serial adapter to enable RS232 communication. Adapter used for connecting to RJ45 style serial interface connector on applicable ION model.

RJ45 Pin	DB9 Pin	Color
1	No Connect	
2	No Connect	
3	3	Black
4	No Connect	
5	2	Green
6	No Connect	
7	5	Brown
8	No Connect	

5.3 Optional Heat Sink

The optional heat sink can be used to increase the continuous output current and power in applications where the ION module is not cold-plate mounted or is operating in high ambient environments. It is especially effective when forced air cooling is available. See Section 7.9, ION/CME Thermal Operating Curves for the ION specifications with and without the heat sink attached.

To enhance thermal conductivity, the heat sink has a thermal pad permanently attached to its mounting surface. The heat sink attaches to the ION enclosure base using the four mounting holes and four M3x10 cross-head screws (supplied). See Figure 5-1and Figure 5-2.

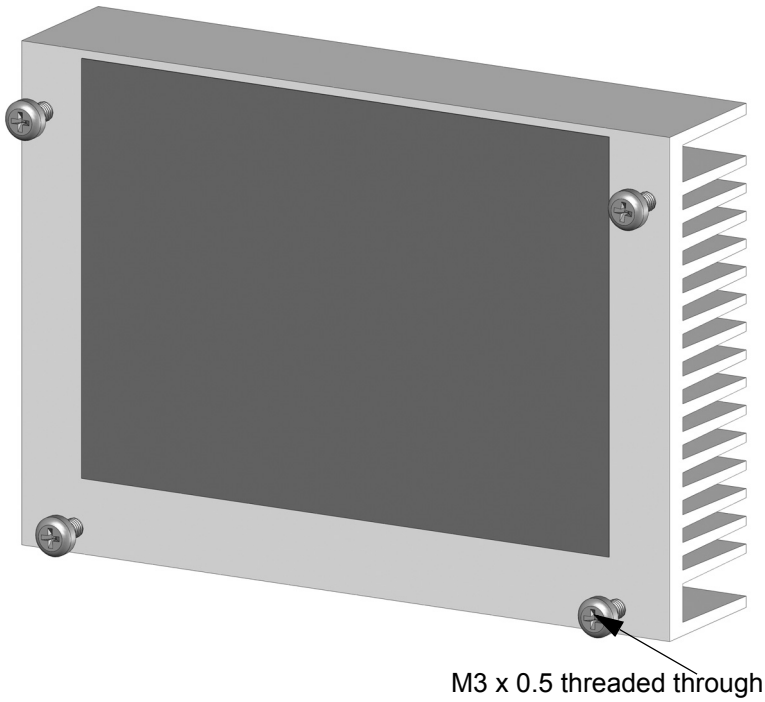


Figure 5-1: ION/CME heat sink

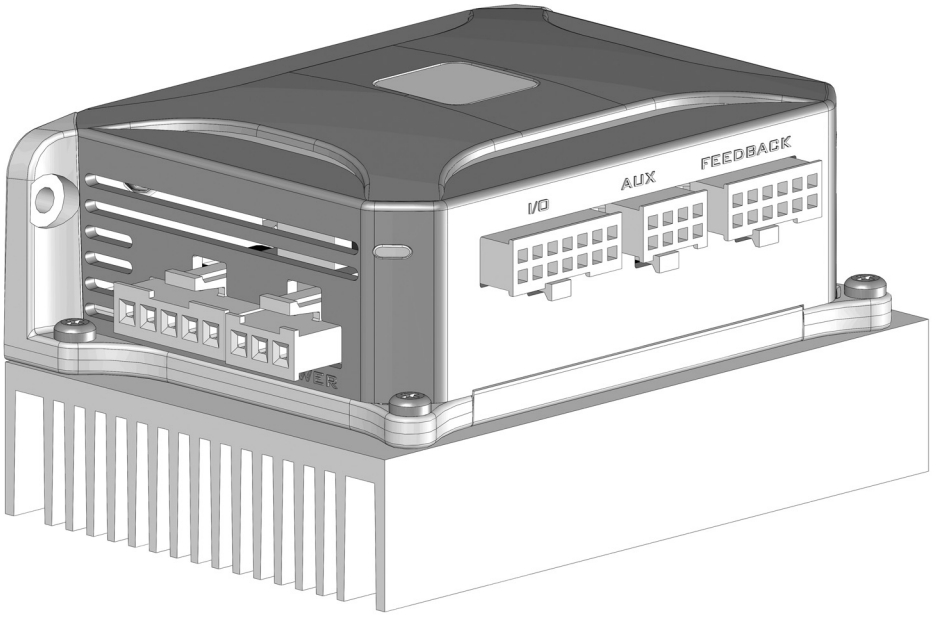


Figure 5-2: ION/CME with heat sink attached

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5.4 Optional DIN Rail Adapter

The optional DIN rail adapter fits on the back of the ION module and allows ION to be mounted to a standard 35mm DIN rail. To install the adapter, place the tab into the large hole in the enclosure and rotate the adapter clockwise as shown in Figure 5-3 and Figure 5-4. The recommended insertion orientation is indicated. When subsequently mounted on a horizontal DIN rail, the Communications connector will be up and the adapter release tab down.

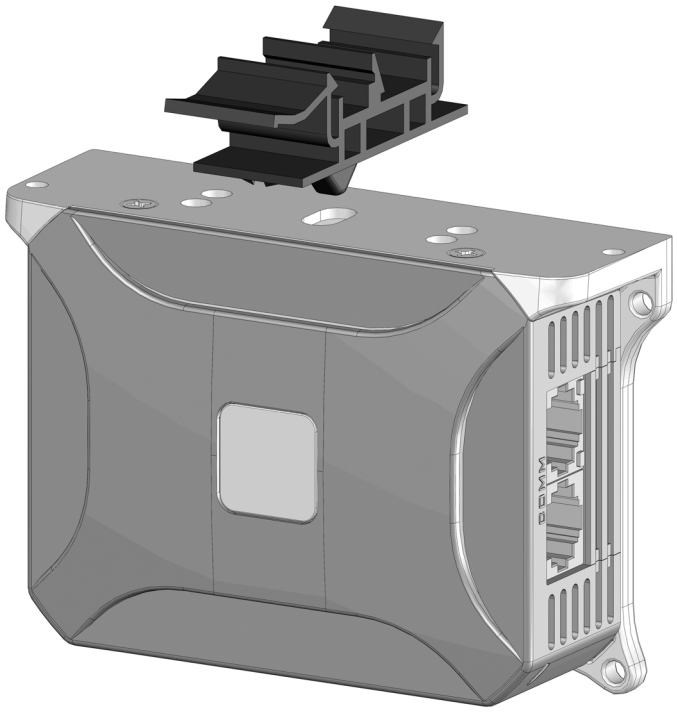


Figure 5-3: Attaching the optional DIN rail adapter

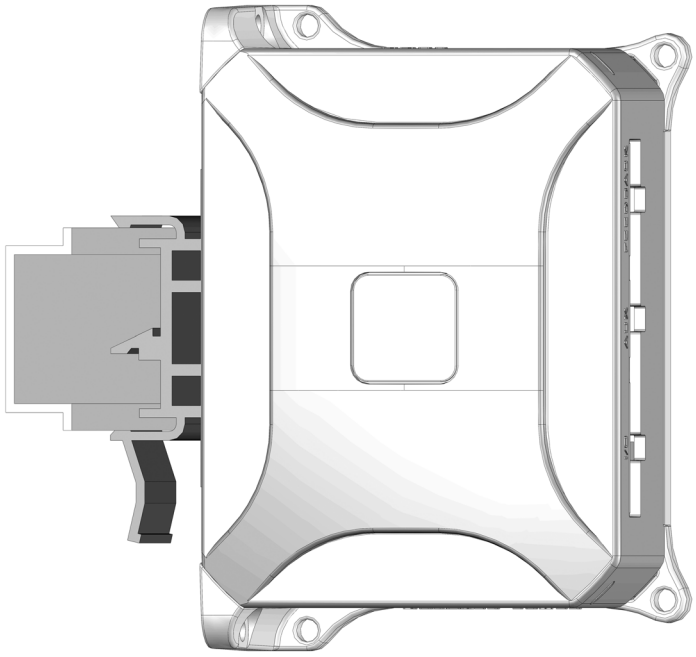


Figure 5-4: ION mounted on DIN rail

To remove the adapter, pry up the two ends while applying rotation force. A flat-blade screwdriver may be required.

6. Electrical Signal Interfacing

In This Chapter

- Motor Feedback
- Auxiliary Position Input
- Limit and Home Inputs
- Position Capture Sources
- AxisIn and AxisOut Signals
- /Enable and FaultOut Signals
- General Purpose Digital Inputs and Outputs
- Analog Inputs

6.1 Motor Feedback

The Feedback connector contains the main encoder signals as well as Hall commutation signals. These signals are buffered and filtered in the Quadrature Signal Conditioning and Digital Signal Conditioning blocks, respectively. ION supports incremental quadrature encoders with count rates up to 10 Mcounts per second, and for the ION 3000 module Pulse & Direction input on the auxiliary position input at up to 10 Mpulses per second.

6.1.1 Main Encoder Inputs

The differential input circuitry for the main encoder A, B and Index signals is shown in Figure 6-1. This circuit accepts both differential and single-ended signals in the range of 0–5V. For single-ended operation, the unused input should be left floating.

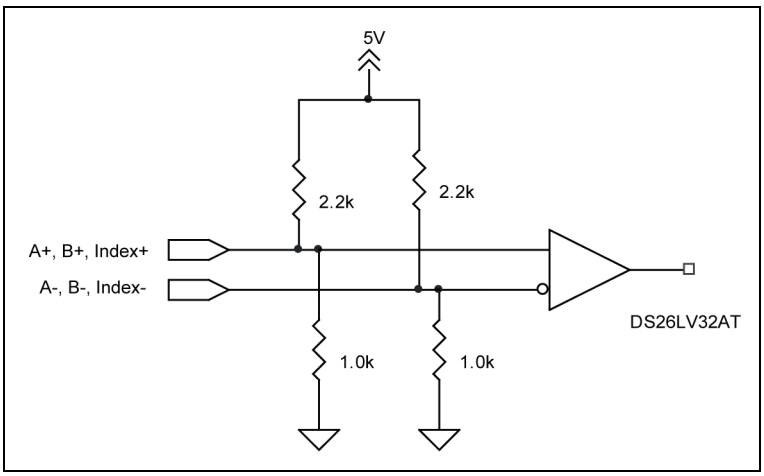


Figure 6-1: Main encoder input circuits

For full functionality, ION requires a three channel (with Index) incremental encoder for the main feedback. The required index alignment is shown in Figure 6-2. ION qualifies the Index with the page 70A and B quadrature inputs and recognizes an Index event when all signals (*A*, *B* and *Index*) are low.

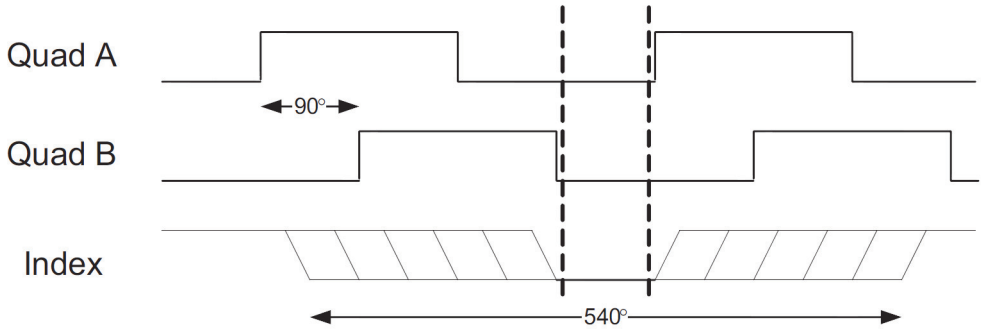


Figure 6-2: Encoder phasing diagram

Correct Index phasing and polarity is required for the ION to operate properly. The A & B channels can be swapped and the quadrature signals inverted as required at the differential inputs to achieve the above phasing alignment.

While the motion processor has the ability to invert the polarity of the A, B and Index signals with a software command, this command cannot be used to alter the index alignment because the inversion takes effect after index qualification.

6.1.2 Hall Inputs

The input buffer for the Hall A, B and C signals is shown in Figure 6-3. This circuit accepts signals in the range of 0–24V and has TTL compatible, Schmidt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and an R-C low pass filter to reject noise.

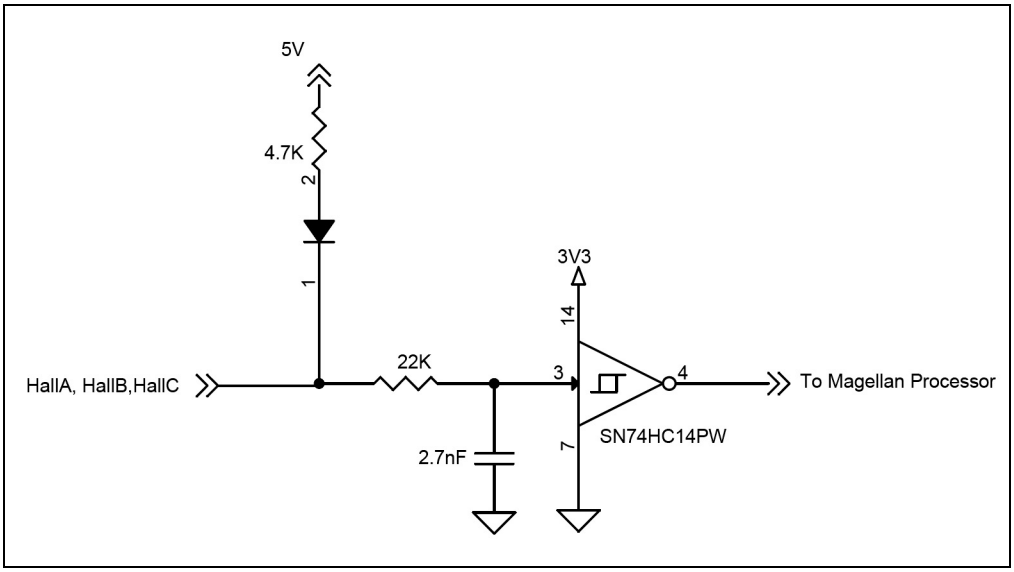


Figure 6-3: Hall input circuits

The Hall signals are only used with brushless DC motors. They are used to directly commutate the motor in 6-step commutation mode or to provide an absolute phase reference for sinusoidal commutation.

6.2 Auxiliary Position Input

The differential input circuitry for the auxiliary position input signals is shown in Figure 6-4. This circuit accepts both differential and single-ended signals in the range of 0–5V. For single-ended operation, the unused input should be left floating.

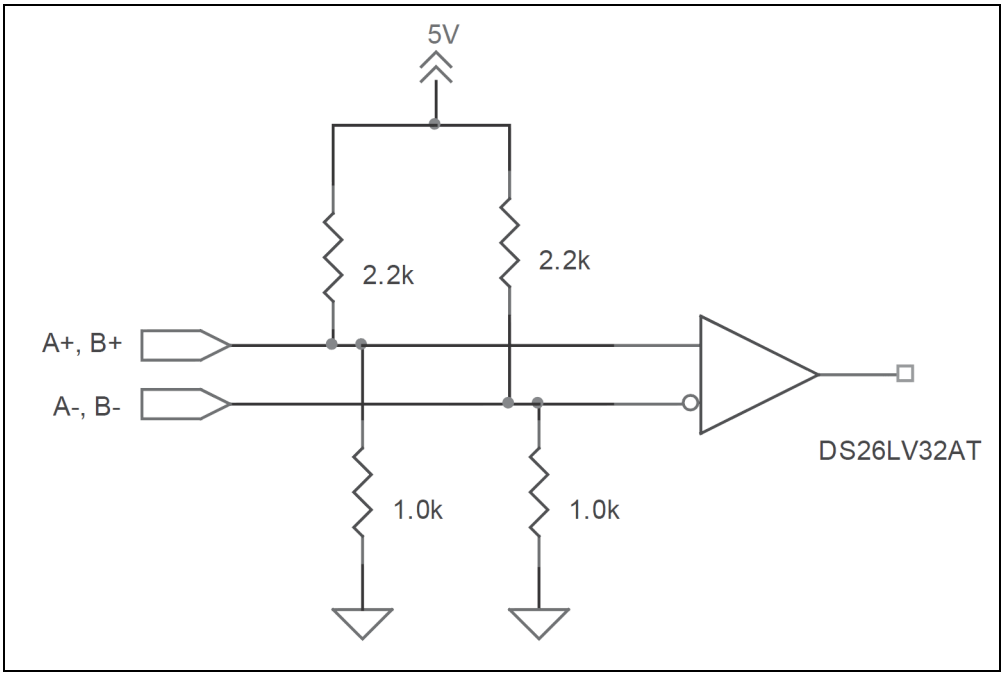


Figure 6-4: Auxiliary encoder input circuits

Auxiliary encoder input is optional and can be used for general-purpose position feedback, as the master in electronic gearing applications, or as part of a dual-loop filter compensation scheme. See the *Magellan Motion Processor User's Manual* for information on these operational modes.

There is no index pulse input on the auxiliary position input.

6.3 Limit and Home Inputs

The input buffer for the end-of-travel limit and home signals is shown in Figure 6-5. This circuit accepts signals in the range of 0–24V and has TTL compatible, Schmidt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and a 1.3 kHz R-C low pass filter to reject noise.

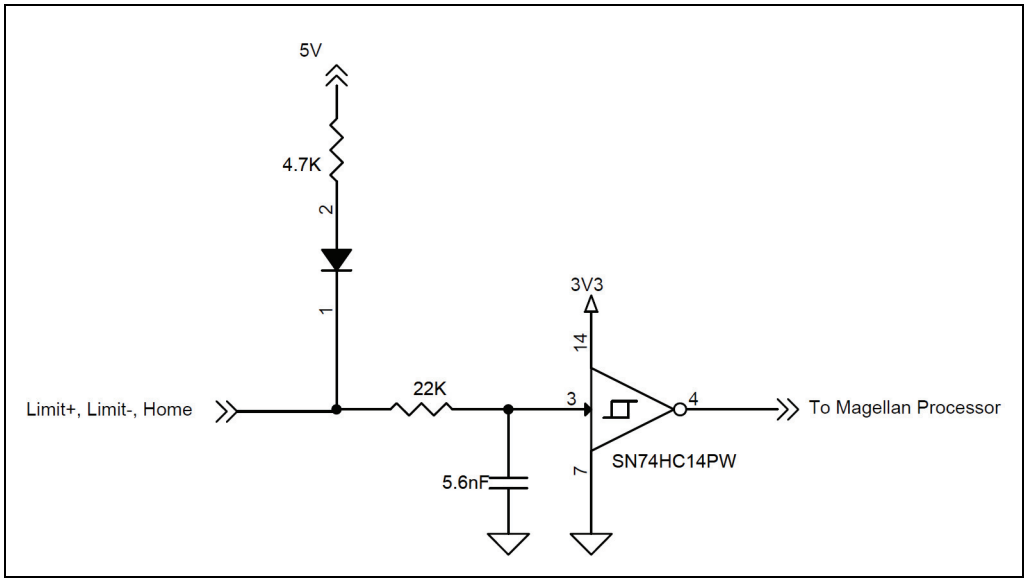


Figure 6-5: Limit and Home input circuits

6.4 Position Capture Sources

The Magellan Motion Processor has the ability to capture the instantaneous position of the main feedback encoder when a trigger is received from a hardware input. The ION module supports three trigger sources: Encoder Index, Home and High-Speed Capture input. The choice of trigger source is selectable through software. The input circuits for *Index* and *Home* are described in sections 6.1.1 and 6.3, respectively.

6.4.1 High Speed Capture Input

This dedicated input is specifically designed for high speed signals. See Figure 6-6. It is similar to the *Home* input with the exception that the R-C low-pass filter bandwidth has been increased to 1.2 MHz. This value is a compromise between noise rejection and trigger latency.

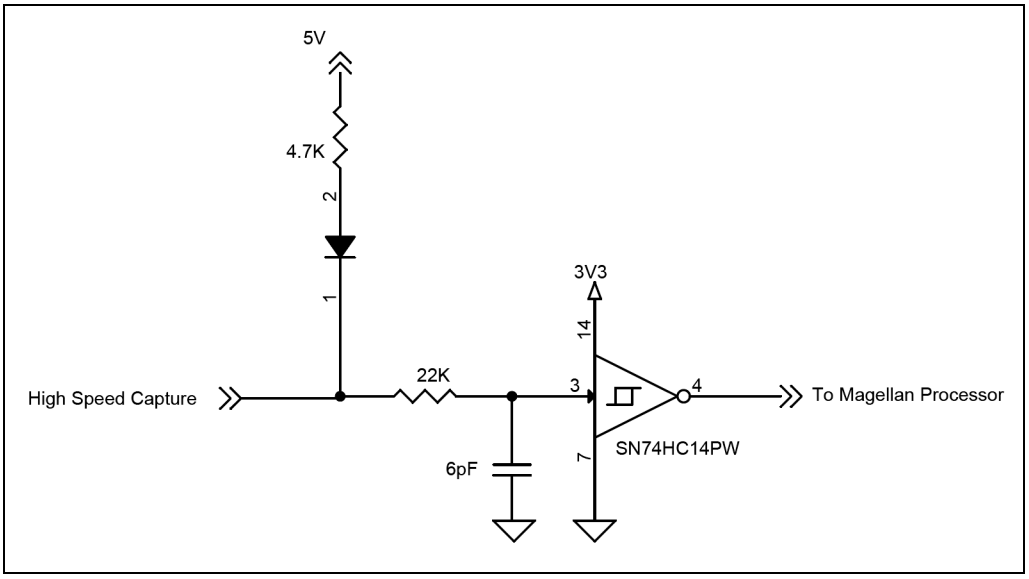


Figure 6-6: High Speed Capture circuit

6.5 AxisIn and AxisOut Signals

The input buffer for the AxisIn signal is shown in Figure 6-7. This circuit accepts signals in the range of 0–24V and has TTL compatible, Schmidt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and a 13 kHz R-C low pass filter to reject noise.

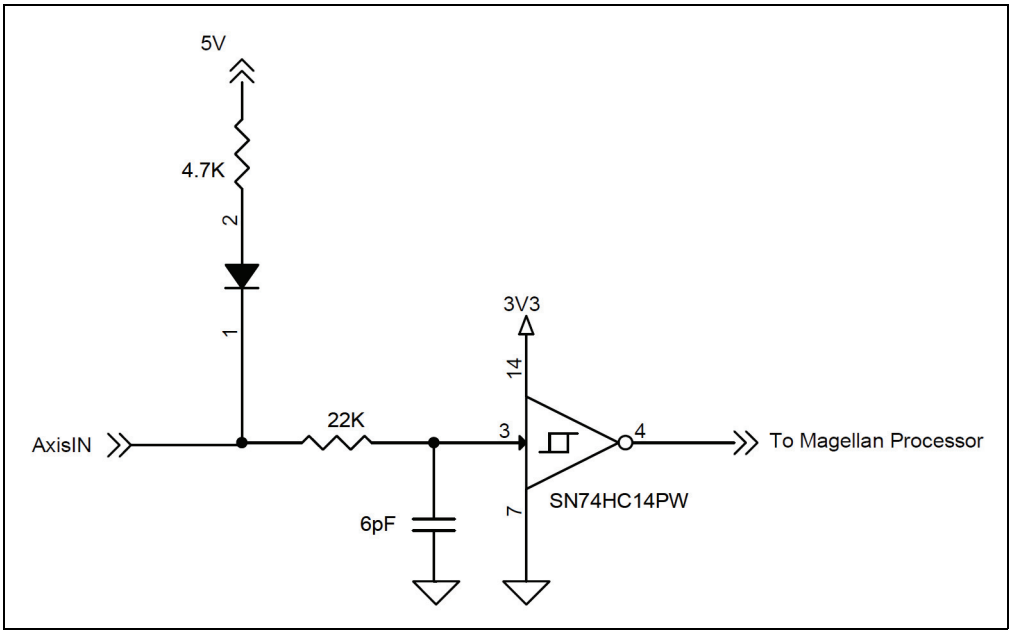


Figure 6-7: AxisIn circuit

The output driver for the ***AxisOut*** signal is shown in Figure 6-8. This circuit can continuously sink over 100mA and source 4mA from a pull-up resistor to 5V. The diode in series with the pull-up resistor allows loads powered from up to 24VDC to be switched. The FET driver is internally protected from shorts up to 30V.

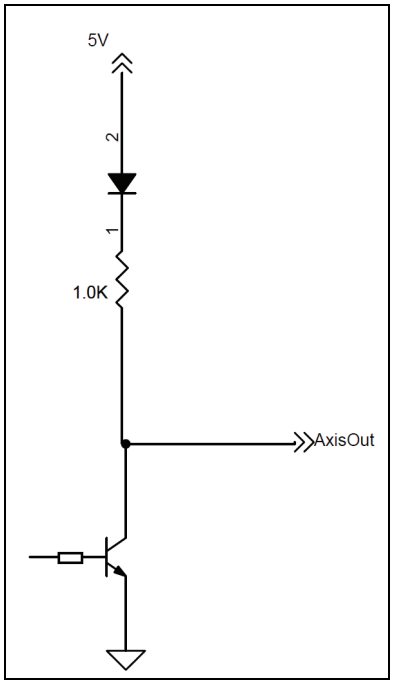


Figure 6-8: AxisOut circuit

AxisIn and *AxisOut* are versatile I/O signals. They are not dedicated to any particular motion control function but can be programmed to implement a wide array of system integration functions. See the *Magellan Motion Processor User's Guide* for more information on configuring and programming these signals.

6.6 /Enable and FaultOut Signals

These dedicated signals are typically used to implement a safety interlock between the ION module and other control portions of the system. */Enable* is an active-low input that must be tied or driven low for the ION output stage to be active. Similarly, *FaultOut* indicates any serious problem by going high. When ION is operating properly, *FaultOut* is low. The polarity of these signals is fixed and cannot be changed via software.

The input buffer for the */Enable* input is shown in Figure 6-9. This circuit accepts signals in the range of 0–24V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector enable sources without the need for an external pull-up resistor and a 1.3 kHz R-C low pass filter to reject noise.

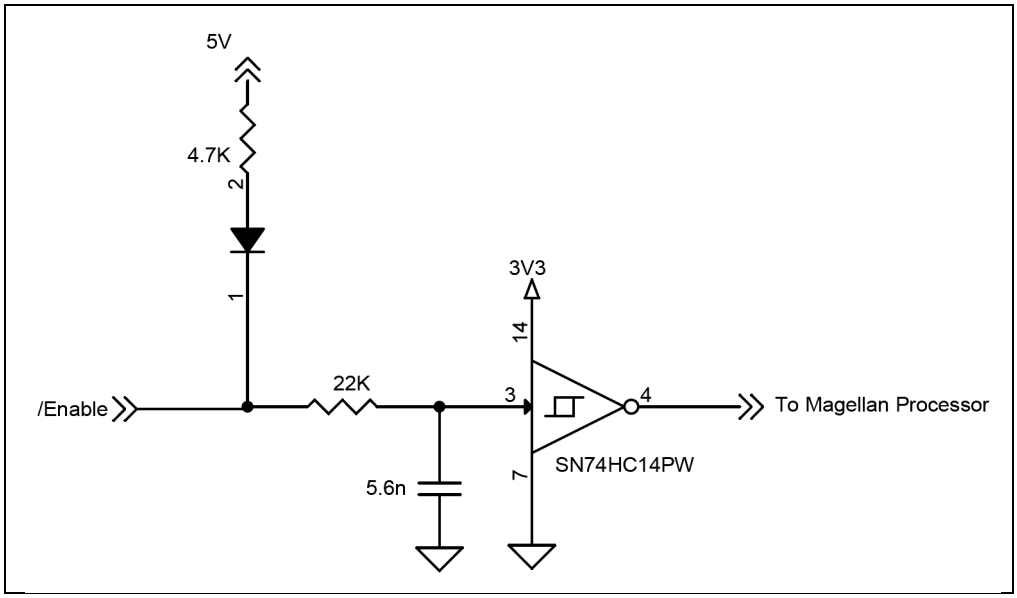


Figure 6-9: /Enable input circuit

The output driver for ***FaultOut*** is shown in Figure 6-10. This circuit can continuously sink over 100 mA and source 4mA from a pull-up resistor to 5V. The diode in series with the pull-up resistor allows loads powered from up to 24VDC to be switched. The FET driver is internally protected from shorts up to 30V.

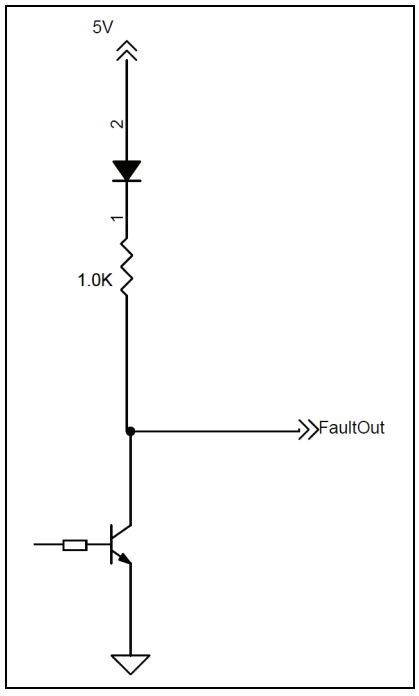


Figure 6-10: FaultOut circuit

When the ION is powered off, FaultOut is effectively high impedance and unable to sink current. This state should be interpreted as "Fault" by the receiving circuit.

6.7 General Purpose Digital Inputs and Outputs

There are four bidirectional general purpose I/Os (GPIO), four Inputs, and two Outputs, available to the ION/CME user. Use of these General Purpose Signals is optional. The signals provide a TTL interface to the application environment of the ION/CME.

Digital Inputs are of single ended type with an internal pull up resistor of 4.7 Kohms to 5V. Refer to Figure 6-11.They feature a low pass RC filter with a corner frequency of 6 KHz, and a Schmitt trigger for noise protection.

Digital Outputs are open collector with an internal 1Kohm pull up resistor to 5V. The maximum allowed sink current is 100mA. Refer to Figure 6-12.

Digital I/Os have a single-ended type input with an internal pull-up resistor of 4.7 Kohms to 5V. Output is open collector with a 4.7 Kohm to 5V. Maximum sink current in output mode is 10 mA. Refer to Figure 6-13.

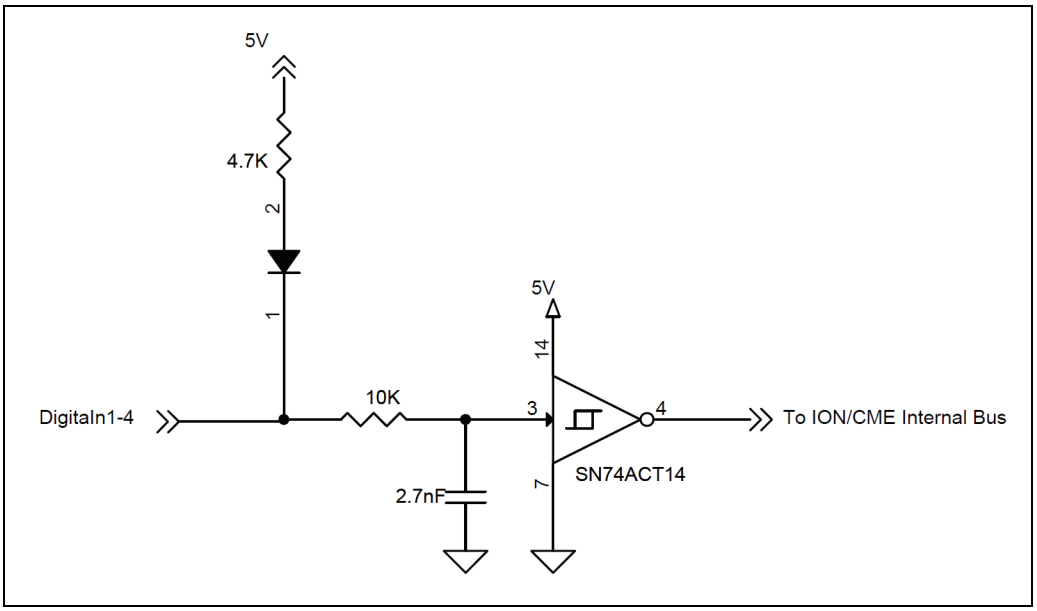


Figure 6-11: Digital inputs circuit

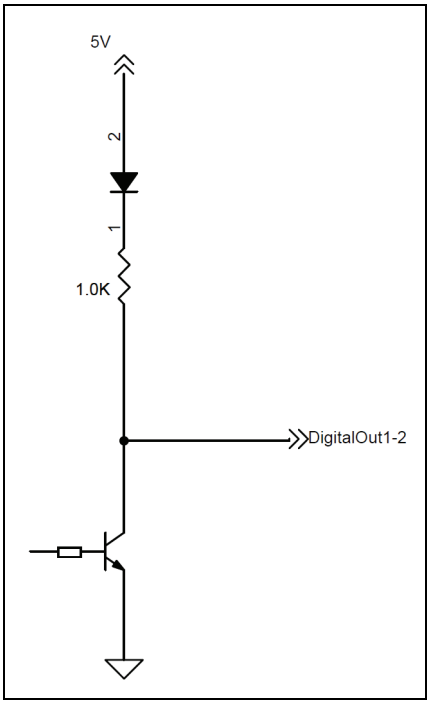


Figure 6-12: Digital outputs circuit

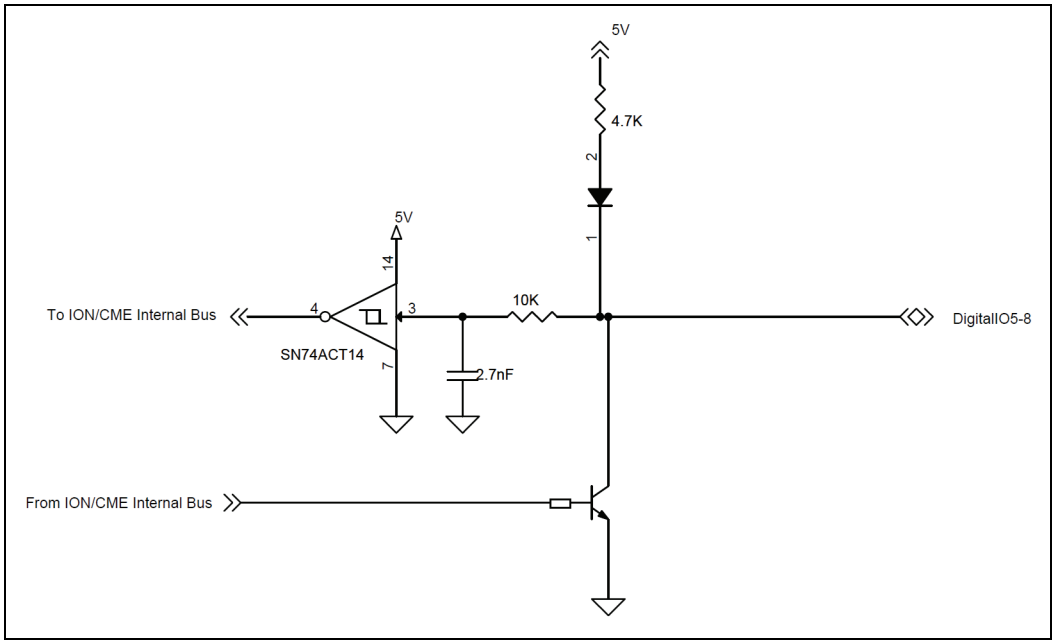


Figure 6-13: Digital I/O circuit

6.8 Analog Inputs

The High Resolution Analog Input has a voltage range of ±10V. The ION/CME receives both single-ended and differential analog inputs as shown in the following table and Figure 6-14. When used in single ended configuration, **AnalogIn-** should be connected to Ground of the transmitter. When used in differential configuration, **AnalogIn+** and **AnalogIn-** are connected to the differential output of the transmitter. In addition, it is recommended to connect the ground of the transmitter to IO_GND of the ION/CME. Refer to the Figure 6-14.

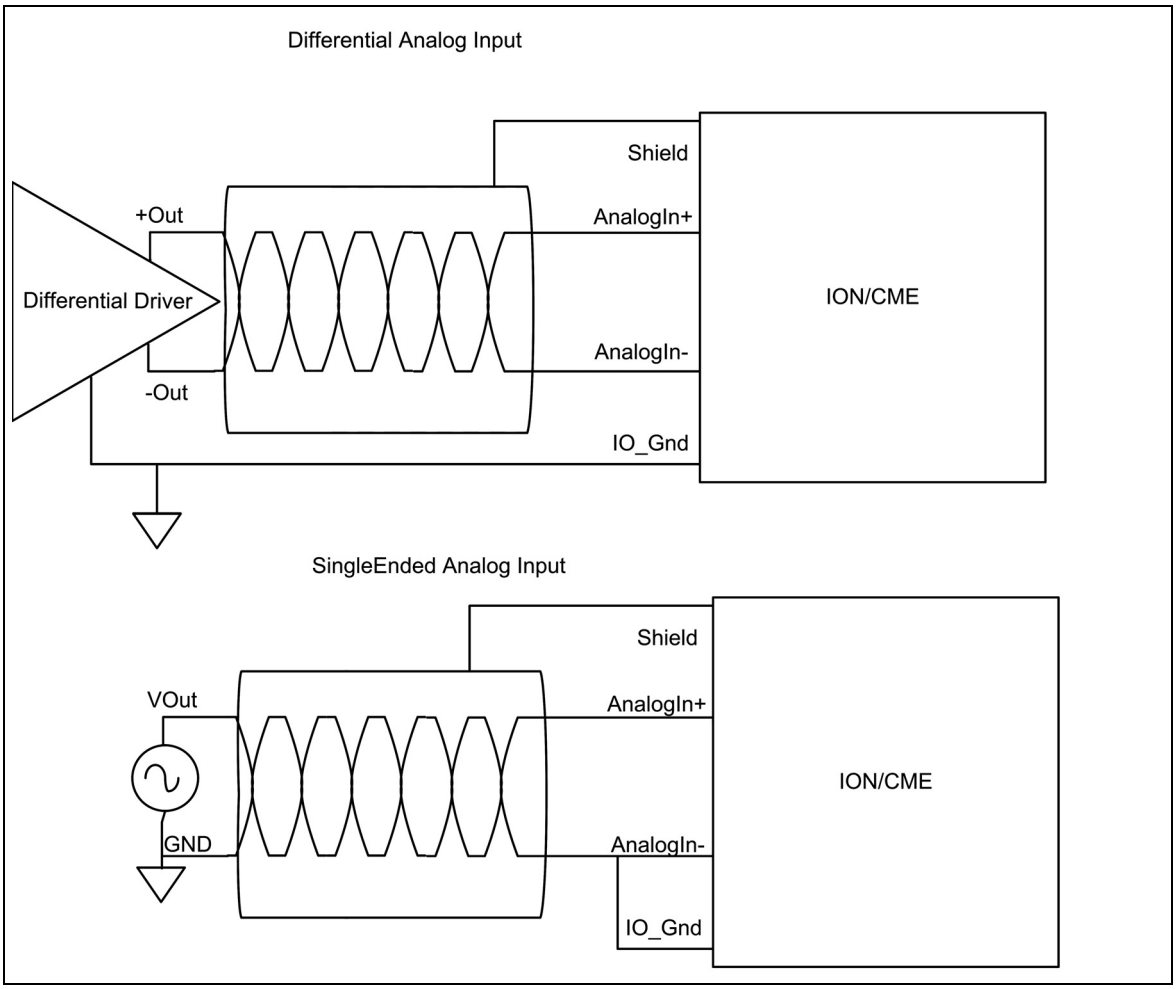


Figure 6-14: Analog inputs simplified diagram

7. ION/CME Specifications

7

In This Chapter

- ION/CME Drive Ratings
- ION/CME Controller Performance
- ION/CME Electrical
- ION/CME Protection Circuits
- ION/CME Connectors and Pinouts
- ION/CME Mechanical
- ION/CME Environmental
- ION/CME Safety and Compliance
- ION/CME Thermal Operating Curves

7.1 ION/CME Drive Ratings

	Motor Model		
Specification	**DC Brush**	**Brushless DC**	**Step**
Nominal supply voltage	48VDC	48VDC	48VDC
Supply voltage range transformer isolated power supply	12–56VDC	12– 6 VDC	12–56 VDC
Output current (per phase) - Continuous, DIN rail mount, w/heat sink, free air @ 25°C	6 ADC	6 Arms (8.5 ADC)	5 Arms (7.1 ADC)
- Continuous, coldplate mount, Tbp<50°C	9.8 ADC	8 Arms (11.3 ADC)	5 Arms (7.1 ADC)
- Peak (2 sec)	21.2 ADC	15 Arms (21.2 ADC)	15 Arms (21.2 ADC)
Maximum continuous output power - Coldplate mount, Tbp<50°C	450 W	500 W	350 W

7.2 ION/CME Controller Performance

Supported motor type	DC brush, Brushless DC, Step motor	
Communications options	Ethernet, RS232/485, CANbus	
Profile modes	S-curve point-to-point	Position, velocity, acceleration, deceleration, jerk parameters
	Trapezoidal point-to-point	Position, velocity, acceleration, deceleration
	Velocity-contouring	Velocity, acceleration, deceleration
	Electronic gearing	Using auxiliary encoder
Position loop filter parameters	Scalable PID with Velocity and Acceleration feedforward, integration limit, offset bias, dual biquad filter, and settable derivative sampling time. Also supports dual encoder feedback.	
Position error tracking	Motion error window	Allows axis to be stopped upon exceeding programmable window.
	Tracking window	Allows flag to be set if axis exceeds a programmable position window.
Configurable loop modes	DC brush and brushless DC motor versions	Position, torque/current and voltage
	Step motor version	Open loop with stall detection, current, and voltage
Digital current loop	Filter parameters	Scalable PI with integration limit and torque/current limit
	Configuration	Standard phase A/B control or FOC with state-vector PWM (user selectable)
	Current feedback scaling	100% full scale equals 21.2A
Current foldback	DC brush and brushless DC motor versions	Programmable I^2t peak limiting
Brushless DC commutation modes	Sinusoidal and 6-step (Hall) commutation	
Microstepping resolution	Up to 256 microsteps per step	
Maximum encoder rate	10 Mcounts per second	
PWM frequency	20 or 40 kHz (user selectable)	
Loop rates	Commutation & current loop	51.2 µsec
	Position loop & trajectory generator	102.4 µsec to 1.67 sec, selectable in multiples of 51.2 µsec from n = 2 to 2^{15}-1

7.3 ION/CME Electrical

AuxV input voltage range	12–56VDC	
AuxV maximum current	0.5A	
IO_5V supply output	5V ±2%, 150 mA (total max.), short circuit protected	
Differential/single-ended encoder inputs	Signals	Main encoder (A+, A-, B+, B-, Index+, Index-)
		Auxiliary encoder (A+, A-, B+, B-)
	Voltage range	0–5 VDC
	Logic threshold	RS422 compatible
	Maximum frequency	2.5 MHz
	Phasing	A leads B by 90°±20°. Index low must align with the A low and B low states and be low for less than 540° total.
Digital inputs	Signals	Hall A, Hall B, Hall C, Home, +Limit, -Limit, AxisIn, High-speed Capture, /Enable
	Voltage range	0–24VDC
	Logic threshold	TTL compatible
Digital outputs	Signal	AxisOut, FaultOut
	Voltage range	0–24VDC
	Output current:	4 mA source, 100mA sink, short circuit protected to 30V
General purpose digital inputs	Available Inputs	4
	Signals	DigitalIn1-4
	Digital Input Type	Single Ended with internal 4.7Kohms pull up to 5V
	Low Pass Filter Frequency	6 KHz
	Logic type	TTL
	Input voltage range	0–24VDC
	Overvoltage Protection	<30V
General purpose digital outputs	Available Outputs	2
	Signals	DigitalOut1-2
	Digital Output Type	Open collector with internal 1k pull-up to 5V
	Maximum Sink Current	100mA
	Overvoltage Protection	<30V

General purpose bidirectional digital Input/output	Available I/Os	4
	Signals	DigitalIO5-8
	Digital Input Type	Single Ended TTL with internal 4.7Kohms pull up to 5V
	Digital Output Type	Open collector with internal 4.7k pull-up to 5V
	Low Pass Filter Frequency	6 KHz
	Maximum Sink Current	100mA
	Overvoltage Protection	<30V
Analog input characteristics	Available Input	1
	Signals	AnalogIn+, AnalogIn-
	Input Signal Voltage Range	-10 to +10V
	Resolution	16 Bits
	Maximum Recommended Input Signal Frequency	2 KHz
	Throughput	40 kSPS
	Integral Non Linearity Error, Typical	+1 LSB
	Integral Non Linearity Error, Maximum	+3 LSB
	Overvoltage Protection	-35 to +40V
	Common-Mode Range	-10 to +25V
	Typical Differential Impedance	108 Kohms
	Common Mode Rejection Ratio, Minimum	80 dB
RS232/485 communications	Baud Rates	1200, 2400, 9600, 19.2k, 57.6k, 115k, 230k, 460k
		Default baud rate is 57.6k.
		460k support for RS485 only
	Isolation	None
	Termination	None
Ethernet communications	Compatibility	100BASE-TX, 10BASE-T

7.4 ION/CME Protection Circuits

Overtemperature	User programmable between 0°–70°C
Overvoltage	User programmable between 20–60V
Undervoltage	User programmable between 10–56V
Overcurrent	Fixed at <= 200% of drive peak rating
Short circuit protection	Line-to-line, line-to-power supply, and line-to-case ground

7.5 ION/CME Connectors and Pinouts

7.5.1 High Power Connectors

Connector: Power
Mating connector mfg/type: Molex MiniFit Jr. plug
Mating connector P/N: 39-01-4031
Wire range, AWG: 16
Recommended crimp terminal: 44476-3112

Pin	Signal
1	+HV
2	AuxV
3	Pwr_Gnd

Connector: Motor
Mating connector mfg/type: Molex MiniFit Jr. plug
Mating connector P/N: 39-01-4051
Wire range, AWG: 16
Recommended crimp terminal: 44476-3112

Pin	Signal
1	Motor+, Motor A, Motor A+
2	Motor B, Motor A-
3	Motor-, Motor C, Motor B+
4	Motor B-
5	Case/Shield

7.5.2 Signal Connectors

Connector: Feedback
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1200
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	Hall A
5	Hall B
6	Hall C
7	Quad A+
8	Quad A-
9	Quad B+
10	Quad B-
11	Index+
12	Index-

Connector: Auxiliary
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-0800
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	No connect
5	Quad A+
6	Quad A-
7	Quad B+
8	Quad B-

Connector: I/O
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1400
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	IO_Gnd
5	IO_5V
6	IO_Gnd
7	FaultOut
8	+Limit
9	-Limit
10	Home
11	High Speed Capture
12	AxisIn
13	AxisOut
14	/Enable

Connector: Indexer
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1600
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Case Shield
2	IO_Gnd
3	IO_5V
4	IAnalogIn-
5	AnalogIn+
6	IO_Gnd
7	DigitalOut1
8	DigitalOut2
9	DigitalIn1
10	DigitalIn2
11	DigitalIn3
12	DigitalIn4
13	DigitalIO5
14	DigitalIO6
15	DigitalIO7
16	DigitalIO8

7.5.3 Communications Connectors

Connector: Serial RS232/485

Mating Connector: Generic RJ45 8-P 8-C

Pin	RS232	RS485
1	Unused	Unused
2	Unused	Unused
3	Rx	Rx+
4	Unused	Tx+
5	Tx	Tx-
6	Unused	Rx-
7	IO_Gnd	IO_Gnd
8	Select = Float/High	Select = low

Connector: Ethernet

Mating Connector: Generic RJ45 8-P 8-C

Pin	Signal
1	Transmit+
2	Transmit-
3	Receive+
4	Unused
5	Unused
6	Receive-
7	Unused
8	Unused

7.6 ION/CME Mechanical

Specification	Value
Dimensions	See Figure 7-1
Weight	
- without heat sink	0.6 lb [0.28 kg]
- with heat sink	1.1 lb [0.5 kg]
Enclosure materials	Aluminum base and molded plastic cover
Mounting options	Coldplate, panel, and DIN rail
Recommended mounting screws	#6, M3, or M3.5
Protection class	IP20

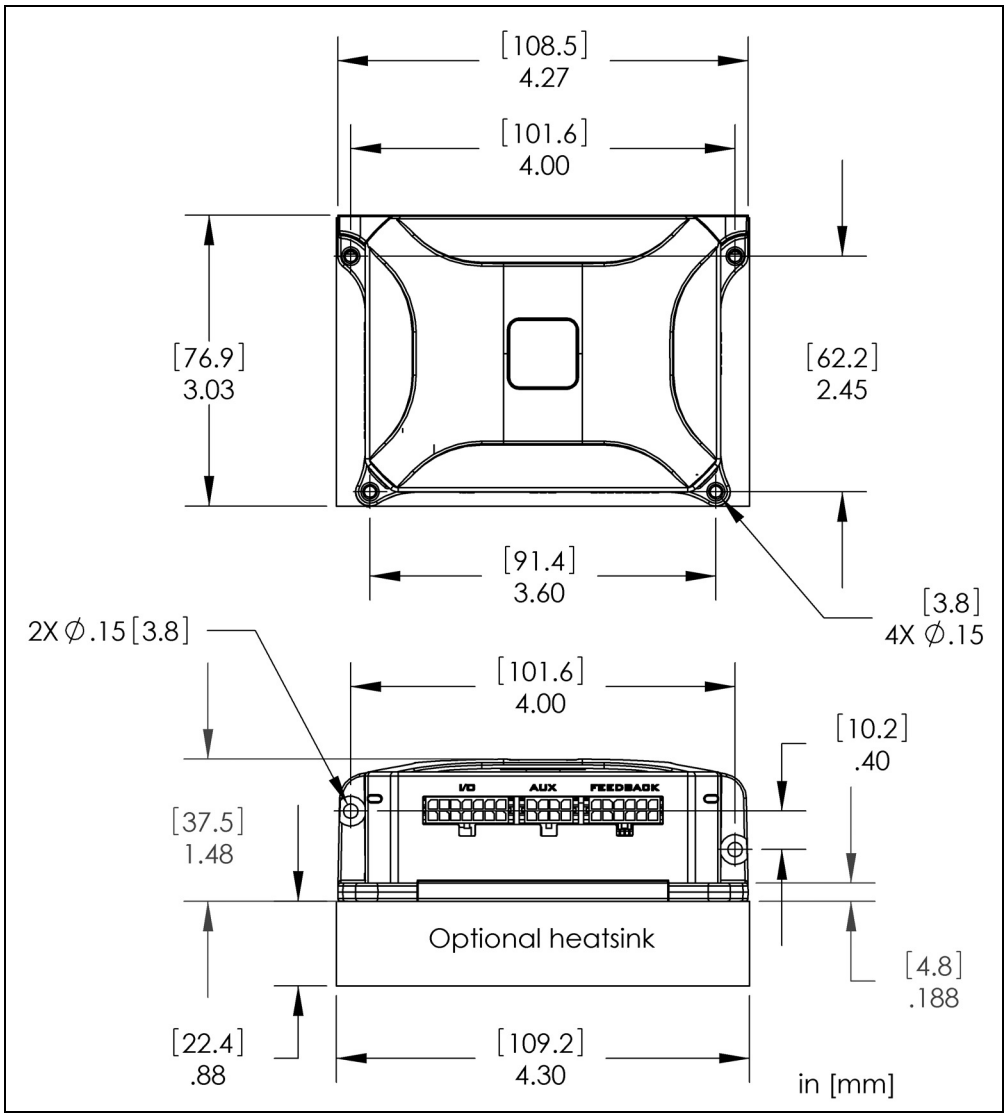


Figure 7-1: ION/CME dimensions

7.7 ION/CME Environmental

Specification	Value
Operating ambient temperature	0°–60°C
Maximum base plate temperature	70°C
Storage temperature	-20° to 85°C
Humidity	0-95%, non-condensing
Altitude	Up to 2000 meters without derating
Contamination	Pollution Degree 2

7.8 ION/CME Safety and Compliance

Specification	Standards
CE	LVD: EN60204-1 EMC-D: EN61000-6-1, EN61000-6-3, EN55011
Electrical safety	Designed to UL508c, UL840, and EN60204-1
Hazardous materials	RoHS compliant
Flammability	UL 94-V2 or V0
Enclosure	IP20

7.9 ION/CME Thermal Operating Curves

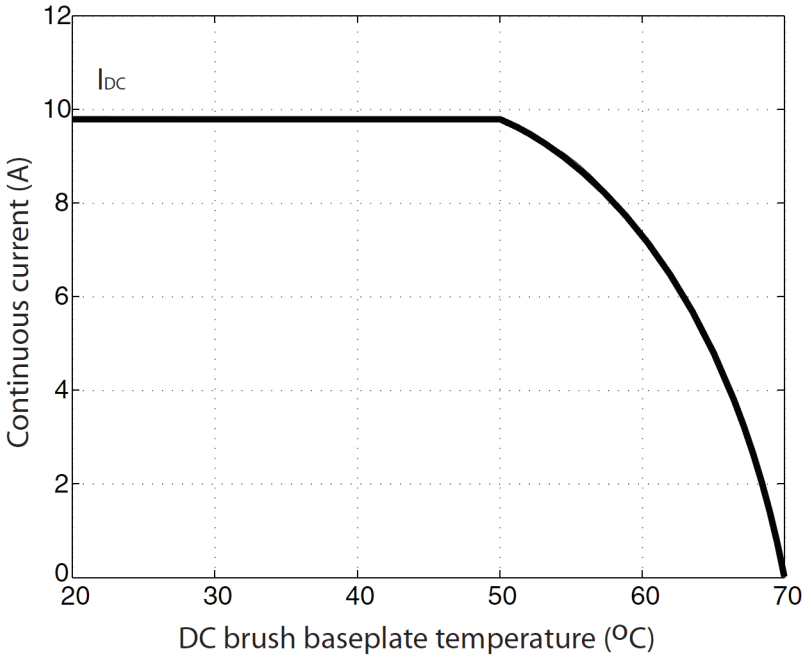
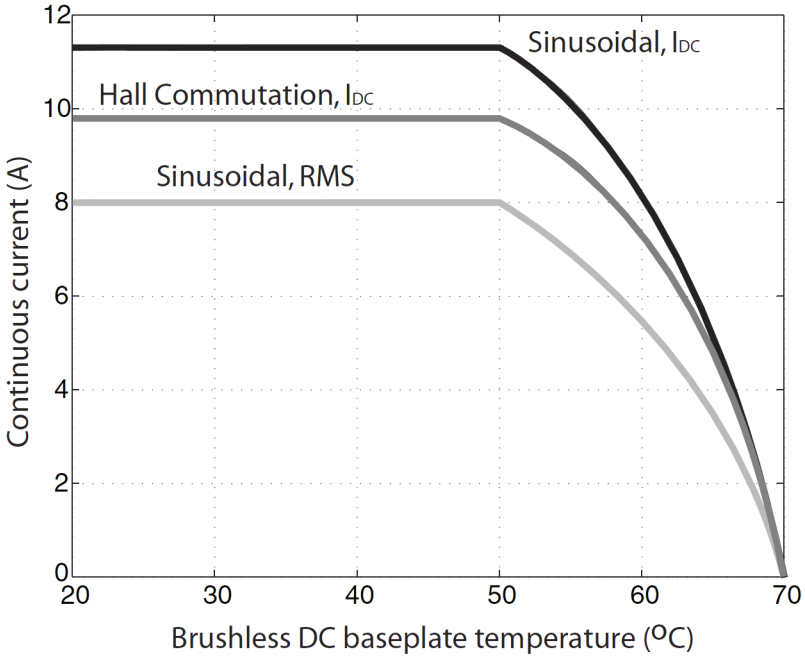
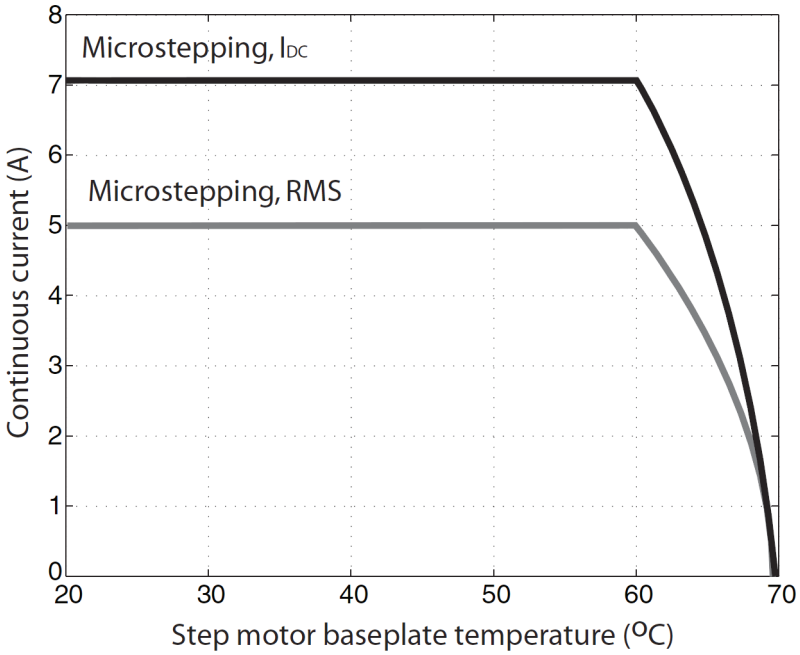


Figure 7-2: ION/CME derating curve for DC brush module



Note: $I_{DC} = 1.414 * I_{RMS}$

Figure 7-3: ION/CME derating curves for brushless DC module



Note: $I_{DC} = 1.414 * I_{RMS}$

Figure 7-4: ION/CME derating curves for step motor module

Index

Symbols
/Enable and FaultOut Signals 74
/Enable input 30
/Enable signal 75

Numerics
3.3V supply monitor44
3-phase bridge 40
4-quadrant operation 40

A
A and B quadrature inputs 69
auxiliary encoder connector 84
    pinouts 20, 84
    wiring 20
Auxiliary Voltage (AuxV) input 16
AxisIn and AxisOut signals 24, 73

B
Block Diagram 39
brushless DC motors
    connection 15
    drive ratings 79
    Hall signals 20, 22
    phase current feedback 40
    power stage configuration 40
buffers
    trace 44

C
cable shield. *See* shielded cable
circuits
    auxiliary encoder input 71
    AxisIn 73
    AxisOut 74
    FaultOut 75
    Hall input 70
    High Speed Capture 73
    limit and home input 72
    main encoder input 69
    protection 83
    reset 44
C-Motion 28
coldplate cooling method 13
Comm ports 26
Comm Status LED 14
communication ports 40

RS232/485 version 26
communications
point-to-point 28
ports 26
status LED 30
commutation, sinusoidal 70
compliance and safety specifications 87
conditions
hard fault 45
operational and fault 45
configurable loop modes 80
connectors
auxiliary encoder 20, 84
by module type 15
Ethernet 26
feedback 18, 83
I/O 24, 84
locator 14
motor 17, 83
power 16, 83
RJ45 26
RS232/485 26
serial 26
controller performance specification 80
convection cooling method 13
current foldback. *See* I^2t current foldback

D

data traces 44
DC brush motors
connection 15
drive ratings 79
phase current feedback 40
power stage configuration 40
DC bus 43
current monitoring 43
overvoltage and undervoltage 43
DC/DC converter 16
Defaults & Limits 42
Developer's Kit 12
diagrams
/Enable input circuit 75
auxiliary encoder input circuits 71
AxisIn circuit 73
AxisOut circuit 74
connector locator 14
dimensions 86
encoder phasing 70
FaultOut circuit 75

Hall Input circuit 70
High Speed Capture circuit 73
Limit & Home circuit 72
ION/CME mounted on DIN rail 68
ION/CME with heat sink attached 67
main encoder input circuits 69
optional DIN rail adapter 68
optional heat sink 67
simplified serial transceiver 40
differential encoder
electrical specifications 81
outputs 20
signals 69
digital inputs and outputs 76
dimensions diagram 86
DIN rail adapter 68
grounding and 13
installation 68
removing 68
disabled condition 45
drive ratings 79
Dual Encoder connection summary 22

E

electrical specifications 81
Enabled condition 45
encoder
auxiliary 71
electrical specifications 81
incremental quadrature 69
main 69
phasing diagram 70
Encoder Connections 20
environmental specifications 87

F

FaultOut signal 24,74
faults, hard 45
feedback connector 83
pinouts 18, 83
wiring 19
forced air cooling method 13
frequency
PWM 40
ripple current 40

G

ground fault 43, 45

H
Hall signals 20, 22, 70
hard electrical faults 45
hard fault state 45
H-Bridge 40
heat sink, mounting optional 67
High Speed Capture 24, 72
Home inputs 72

I
I/O connector
  pinouts 24, 84
  wiring 24
I^2t current foldback 41
  energy limit 41
incremental quadrature encoders 69
index
  alignment 69
  event 69
  phasing 70
inputs
  /Enable 30
  A and B quadrature 69
  auxiliary encoder 71
  digital 76
  Hall 70
  High Speed Capture 24, 73
  limit and home 72
  main encoder 69
  quadrature 69
installation
  applying power 29
  communications configuration 28
  configuration and mounting 13
  connector pinouts 14
  DIN rail adapter 68
  hardware requirements 12
  model numbers 11
  software 28
  status LEDs 30
  wiring 14
Internal Logic Fault 45
IO_5V 24
  auxiliary encoder connector 20
  fault 45
  feedback connector 18
  Indexer connector 25
  I/O connector 24
  monitor 44

power connector 16

L

LEDs
communications (Comm) status 14
hard electrical faults 45
Module Status 30
operational and fault modes 45
limit input 72
loop rates 80

M

main encoder input circuits 69
main encoder signals 69
mechanical specifications 86
microstepping drive
connection 15
model numbers 11
modes
configurable loop 80
fault 45
operational 45
Module Status LED 30
monitor
3.3V supply 44
IO_5V 44
MOSFET power stages 40, 41
motor case wire 17
motor connector
applying power 29
pinouts 17, 83
wiring 17
Motor Feedback 69
mounting
cooling methods and 13
dimensions diagram 86
DIN rail adapter 68
mechanical specifications 86
optional heat sink 67
recommended surface 13
multi-drop networking 40

N

networking
configurations 28
multi-drop 40
termination 28, 29
noise
minimizing electrical 13, 17, 25, 26
R-C lowpass filter 70

O
operating temperature 41
orientation, recommended 13
outputs
    differential encoder 20
    digital 77
    single-ended 20
overcurrent fault 45
overtemperature protection 41
overtravel limits 24, 41
overvoltage threshold 43

P
packets, communications 30
phase current feedback 41
pinouts 14
    auxiliary encoder connector 20, 84
    feedback connector 18, 83
    I/O connector 24, 84
    Indexer connector 25, 84
    motor connector 17, 83
    power connector 16, 83
point-to-point communications 28
ports, communication 40
Position Capture Sources 72
position error tracking 80
power
    applying 29
    overvoltage threshold 43
power connector
    pinouts 16, 83
    wiring 16
powerup
    module status LED 30
profile modes 80
Pro-Motion application
    CD 28
protection circuits 83
PWM
    frequency 40
    ripple current 40
    switching scheme 40
PWM Power Stage 40

Q
quadrature
    A and B inputs 69
    encoders 20
    incremental encoders 69

R
R-C lowpass filter bandwidth
/Enable and FaultOut signals 74
Hall inputs 70
high speed capture input 72
limit and home inputs 72
reset condition 44
RJ45 connector 26
RS232/485 connector
communication ports 26
electrical specifications 81
wiring 27

S
safety and compliance specifications 87
safety interlocks 74
servo motors 40
shielded cable 15
auxiliary encoder connector 20
feedback connector 18
I/O connector 24
Indexer connector 25
motor connector 17
signal connectors 83
Single Encoder connection summary 20
single-ended
auxiliary encoder signals 71
encoder inputs 69
sinusoidal commutation 70
software installation 28
specifications
controller performance 80
drive ratings 79
electrical 81
environmental 87
mechanical 86
safety and compliance 87
status LEDs 30
step motors
automatic holding current reduction 41
drive ratings 79
phase current feedback 41
power stage configuration 40
stub cable 63

T
temperature sensors 41
Thermal Operating Curves 87
Trace Buffer 44

trace capture 44
trigger latency 72
trigger sources 72

U
undervoltage, condition and threshold 43

W
wiring
applying power 29
auxiliary encoder connector 20
feedback connector 18
I/O connector 24
Indexer I/O 25
motor connector 17
power connector 16
recommended auxiliary encoder 20
recommended feedback 19
RS232/485 wiring 27
typical I/O 24
typical motor 17
typical power 16

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